THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE III. VOL. X.

No. IV.—APRIL, 1893.

ORIGINAL ARTICLES.

I.—Notes on the Devonian Fishes of Campbelltown and Scaúmenac Bay in Canada.—No. 2.[1]

By R. H. Traquair, M.D., F.R.S., F.G.S.

MR. DAMON of Weymouth having recently received a third consignment of fossil fishes and Fish-remains from the Devonian Rocks of Canada, an interesting selection has been made for the Edinburgh Museum, and I am thus enabled to contribute some additional notes regarding the palæozoic ichthyology of this region. The specimens were, as before, collected by Mr. Jex.

Fishes from the Lower Devonian of Campbelltown.

Protodus Jexi, A. S. Woodward.

Geol. Mag. Dec. III. Vol. IX. 1892, pp. 1–2, Pl. I. Figs. 1, 1*a*.

A great many specimens of this tooth have been last summer collected by Mr. Jex. That it is a selachian tooth is proved beyond doubt, not merely by its shape, but by its occasionally occurring in transverse bands, three or four being in apposition in a row back to front.

Doliodus problematicus (A. S. Woodward).

Diplodus problematicus, A. S. Woodward, *op. cit.* p. 2, Pl. I. Fig 2.

Only a single specimen of this curious tooth was at Mr. Smith Woodward's disposal, and that too only exhibiting the crown and denticles, being destitute of the root. The cusps certainly resemble those of *Diplodus* in form and arrangement, but the peculiar form of the base, which is well shown in many of the specimens now before me, is very different, and necessitates the institution of a new genus, which, on account of the deceptive appearance of the first described example, I propose to name *Doliodus*.[2]

Instead of the thick solid base of *Diplodus* we have here a broad thin plate, convex anteriorily and above, concave posteriorly and below, to the upper margin of which the crown is attached. The type specimen has only one intermediate cusp, but their number may vary from one to three or even four.

In connection with the generic separation of this form of tooth from *Diplodus*, Ag., it is interesting to observe that although during his last visit to Canada, Mr. Jex obtained a large number of these teeth, not one example of a Pleuracanth spine has occurred in the

[1] For No. 1 see Geol. Mag. Dec. III. Vol. VII. 1890, pp. 15–22.

[2] Gr. Δόλιος a deceiver.

same beds. I therefore doubt its being even referable to the family Pleuracanthidæ.

? *Cheiracanthus costellatus*, sp. nov.

Several detached spines and one fish wanting the head constitute the remains of this interesting species, which are contained in the present collection.

The fish measures four inches in length, but it is so distorted and shortened up that its real dimensions and contour cannot be determined. Six spines are shown, which I interpret as two pectoral, two ventral, one dorsal, and one anal. The spines are large and rather slender; the pectoral measuring $1\frac{3}{8}$ inch in length and $\frac{1}{8}$ inch in breadth about the middle, the dorsal $2\frac{1}{8}$ inches. The others are imperfect, but all are remarkably straight save the pectoral, which is gently curved. The exposed surface of the spines is marked by prominent longitudinal ridges and furrows, there being four to six on each side, while the median one along the anterior aspect of the spine is broader than the others. There are two clavicular elements near the pectoral spines which resemble in form rather more those of *Cheiracanthus* than of *Acanthodes*. The scales are marked on their exposed surfaces with extremely fine striæ, which are only visible under a strong lens, and pass longitudinally across the scale in a direction parallel to the diagonal, connecting the anterior and posterior angles.

On first seeing the spines I thought of Whiteaves's *Homacanthus gracilis* from the same beds; but they are more slender and have less of a "conical" shape than the spine figured by that author; besides which there are no signs of posterior denticles. It is unfortunate that the fish is so distorted that the relative position of the spines, and especially of the dorsal, with regard to the anal is obscured, so that its reference to *Cheiracanthus* must of course be considered as merely provisional; indeed against this reference may be mentioned the fact that, in their strongly fluted character, the spines rather deviate from those of the well known Scottish species *Ch. Murchisoni* and *Ch. latus*.

Cephalaspis Campbelltownensis, Whiteaves.

Whiteaves, Canadian Nat. n.s. vol. x. p. 98; and Trans. Roy. Soc. Canada, vol. vi. sect. iv. p. 92, pl. x. fig.

In my former paper I recognized two distinct species of *Cephalaspis* from the Campbelltown beds, one having the cephalic shield rounded in front, the other in which it assumed a pointed form like the snout of a skate. Mislead by Mr. Whiteaves's figure, I referred the former to his *C. Campbelltownensis*; to the latter I attached the name of *C. Whiteavesi*.

Mr. Smith Woodward having had subsequently the privilege of inspecting the original type of *C. Campbelltownensis*, found that it actually possessed the pointed rostrum characteristic of my *C. Whiteavesi*, which rostrum had been omitted in the drawing published by Mr. Whiteaves.[1] Consequently my species had to go,

[1] A. S. Woodward, Cat. Foss. Fishes Brit. Mus. pt. ii. p. 191.

though it was clear that there was something still to be determined regarding the species of *Cephalaspis* occurring at Campbelltown.

The mystery is quite cleared up by the specimens in the present collection; there *are* two species, but the new one is that with the *rounded* snout, which I shall describe under the name of

Cephalaspis Jexi, sp. nov.

Cephalic shield rounded in front, cornua incurved, comparatively short and stout; the orbits relatively smaller than in *C. Campbelltownensis*, situated nearly midway between the anterior and posterior extremities of the shield. The external ornament of the shield consists of minute closely set tubercles often tending to be arranged in concentric lines which are parallel to the borders of the tesserae. On the cornua the tubercles are not so close, showing intervals which are finely longitudinally striated. The inner margins of the cornua are distinctly denticulated.

In *C. Campbelltownensis*, on the other hand, the front of the shield is produced into a pointed rostrum, the cornua are relatively longer, the orbits relatively larger than in the preceding species. The ornamentation of the cornua and the denticulation of their inner margins is more delicate, the former consisting of minute pits and reticulating furrows, the interspaces between which appear as minute flattened tubercles.

Both of these species seem to be common at Campbelltown, but perfect shields of *C. Jexi* are rare, being mostly broken on one side, or else distorted by pressure; whereas those of *C. Campbelltownensis* more commonly retain their contour complete. As the name *Whiteavesi*, having dropped, cannot according to the rules of nomenclature be again applied to a different species of *Cephalaspis*, I have pleasure in dedicating this new one to Mr. Jex.

Phlyctænaspis Acadica, Whiteaves.

Coccosteus Acadicus, Whiteaves, Trans. Roy. Soc. Canada, vol. vi. sect. iv. p. 93, pl. ix. and woodcut.

Phlyctænaspis Acadica, Traquair, Geol. Mag. Dec. III. Vol. VII. pp. 20 and 60, Pl. III. Figs. 1, 2.

Phlyctænaspis acadica, A. S. Woolward, Cat. Foss. Fishes, British Museum, pt. ii. p. 295. Also in Geol. Mag. Dec. III. Vol. VIII. 1891, p. 5.

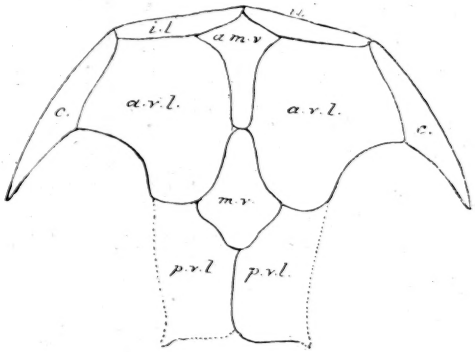
This collection is rich in remains of *Phlyctænaspis Acadica*, among which are some specimens which throw fresh light upon the structure of this interesting and still imperfectly known genus.

One of them shows a large portion of the ventral shield with nearly all its plates *in situ*, and from it, along with detached plates, I have drawn the accompanying restoration, which clears up, I think, certain important points recently discussed by Mr. Smith Woodward.

This specimen shows the left anterior ventro-lateral plate and part of the right one, also the median ventral plate and the greater part of the posterior ventro-lateral plate of the left side, and finally the left lateral spine or cornu in connection with the corresponding anterior ventro-lateral.

The anterior median ventral is not here exhibited, but as it occur detached in another specimen I have in the figure inserted it in its place. The median ventral is however well shown in position, and detached examples of it occur showing both outer and inner aspects. Both of these median plates closely resemble the corresponding plates in *Coccosteus*.

So does the anterior ventro-lateral (*a. v. l.*) which is quite correctly identified by Whiteaves (*op. cit.* pl. ix. fig. 3). Now attached to the antero-external margin of this plate is seen the spine-like body recently described by Mr. Smith Woodward. This spine occurs not only in the specimen on which the above restored sketch is founded, but in the collection now before me is found both absolutely detached, and also in articulation with otherwise isolated examples of the anterior ventro-lateral plate.



Phlyctænaspis Acadica, Whiteaves; restoration of ventral carapace. *a.v.l.* anterior ventro-lateral plates; *p.v.l.* posterior ventro-lateral, not defined in the outer margin in the fossil; *a.m.v.* anterior median ventral; *m.v.* median ventral; *i.l.* interlateral; *c.* cornu or lateral spine.

Mr. Woodward mentions these spines as "each apposed to a lateral plate of the trunk:" it is now shown to *which* lateral plate, as well as to which part of the dermal armour of *Coccosteus*, they correspond.

It will be seen that the spine (*c*) touches with its proximal extremity a narrow portion of bone (*i. l.*) which is articulated with the anterior margin of the anterior ventro-lateral plate (*a. v. l.*). On turning to my previous restoration of the ventral cuirass of *Coccosteus decipiens*, Ag.[1] it will at once be seen that this portion of bone corresponds exactly to the anterior-inferior part of the interlateral plate, (*i. l.*) which occupies the same position with regard to the anterior ventro-lateral, and meets its fellow of the opposite side in front of the anterior median ventral (*a. m. v.*) while the spine in like manner corresponds to the short process which passes backwards separating the anterior ventro-lateral below from the antero-lateral above. This process, short in *C. decipiens*, is more largely developed in *C. minor*, H. Miller, in which species I have stated that it has a "very spine-like appearance," though owing to the proportionally greater

[1] Ann. and Mag. Nat. Hist (6) vol. v. 1890, pl. x. fig. 3.

extent of the margins of the antero-lateral and anterior ventro-lateral plates with which it articulates, it forms no more of an independent projection than in the former.[1] But as in *Phlyctænaspis* this spine seems divided by a very distinct suture from the interlateral plate, I have carefully examined the suite of specimens, both of *Coccosteus decipiens* and *C. minor* in the Edinburgh Museum, with the result that I have convinced myself that the process in question is here also a distinct element, to which the name of "lateral spine" may appropriately be given. In both genera it is immovably fixed; in one example of *Phlyctænaspis* it seems indeed anchylosed to the interlateral plate.

Consideration of this element of the cuirass of the Coccosteidæ calls up of course the question of *Acanthaspis*, Newberry. Mr. Smith Woodward[2] remarks that the spines of *Phlyctænaspis* "are indeed precisely similar in external form and appearance to those of *Acanthaspis*; and so far as can be judged from known specimens they only differ from the last-mentioned spines, in the circumstance that the supporting plate is destitute of the extended oblique pedicle observed both in the type specimens from the Corniferous Limestone of Ohio, and in the shield assigned to the same genus from Spitzbergen. It thus remains to discover more associated examples of the plates and spines from Ohio, to determine whether they actually pertain to Ostracoderms, as suspected, or whether they represent part of the armour characteristic of Arthrodira; for the fixed spinous appendage is now proved to occur in both of these widely separated groups."

It will be remembered that Mr. Woodward, in a previous paper,[3] was inclined to consider *Acanthaspis* as being "most nearly related to the Asterolepidæ, and its spine-like processes to be the homologue of the well-known pectoral-paddles of the latter." But a comparison of Newberry's figures with the sketch of the ventral cuirass of *Phlyctænaspis* given above will remove all doubt as to the Coccostean character of the remains from the Corniferous Limestone of Ohio; figures 1, 2, 3, and 4 on plate lv. of Prof. Newberry's work[4] representing obviously the lateral spine in conjunction with the anterior ventro-lateral plate of a creature allied to the Canadian genus, though the supporting plate is remarkably short from before backwards. The same view must, I think, be adopted for Mr. Woodward's *Acanthaspis decipiens* from Spitzbergen, so that I cannot consider the occurrence of a fixed spinous appendage to be as yet proved in any genus specially allied to the Asterolepidæ. Whether this fixed spine is in any way homologous to the articulated appendage of Asterolepidæ, or to the pectoral limb of vertebrates in general, I need not at present discuss.

Associated with other plates of *Phlyctænaspis Acadica*, are several fragments of dentigerous bones, showing small, smooth-pointed conical teeth in one row.

[1] R. H. Traquair (Geol. Mag. Dec. III. Vol. VI. Pl. I. Fig. 3.
[2] *Op. cit.* p. 481.
[3] "Devonian Fish-Fauna of Spitzbergen," Ann. and Mag. Nat. Hist. (6) vol. viii. pp. 1–15.
[4] Geol. Survey of Ohio, Palæontology, vol. ii.

II.—Restorations of *Anchisaurus*, *Ceratosaurus*, and *Claosaurus*.

By Professor O. C. Marsh, M.A., Ph.D., LL.D., F.G.S.

(PLATES VI. & VII.)

A NUMBER of restorations of dinosaurian reptiles have been recently made by the writer, based upon American specimens which he has personally investigated. Reduced figures of three of these restorations have already appeared in this Magazine; namely, *Brontosaurus* and *Stegosaurus* from the Jurassic, and *Triceratops* from the Cretaceous. Three others of interest are given in the present Number; *Anchisaurus* from the Triassic, *Ceratosaurus* from the Jurassic, and *Claosaurus* from the Cretaceous. The last is a gigantic herbivorous reptile, a typical member of the *Ornithopoda*, and one of the American allies of *Iguanodon*. The other two are carnivorous forms of the order *Theropoda*, as defined by the writer. *Ceratosaurus* has apparently its nearest European ally in *Megalosaurus*, while *Anchisaurus* appears most nearly related to *Thecodontosaurus*.

The three restorations here represented are each based upon the remains of a single individual, which were nearly or quite complete when found, and apparently in the position in which each animal died. The skull and the greater part of each skeleton were secured, and the portions lost are represented in allied

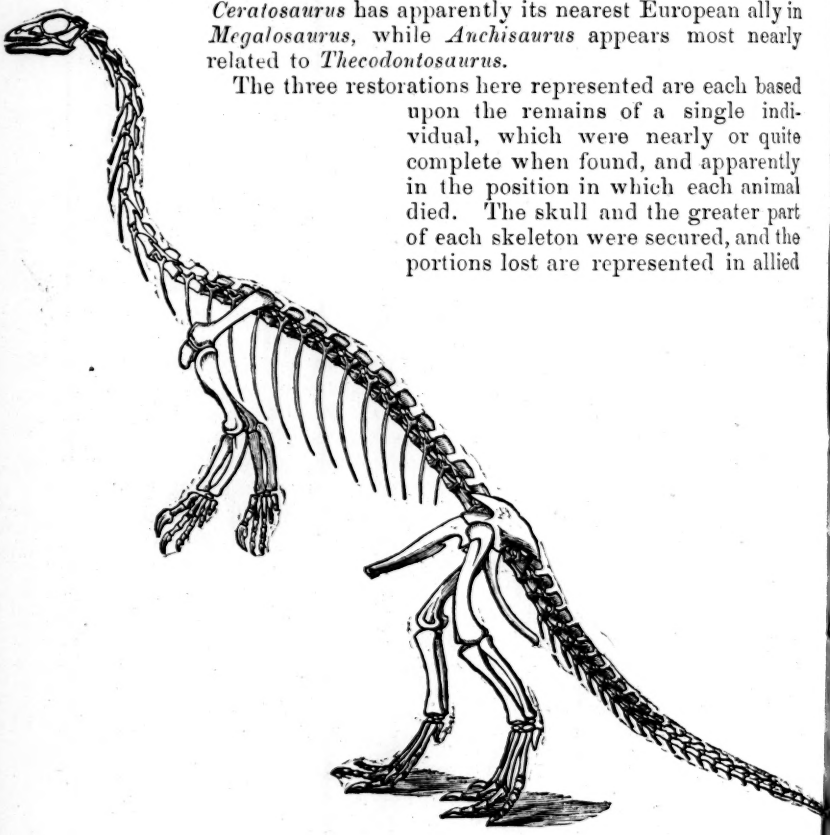


Fig. 1.—*Anchisaurus colurus*, Marsh. $\frac{1}{12}$ nat. size.
From the Upper Triassic Sandstone, Connecticut, U.S.A.

forms from the same localities, so that the chances of error in the restorations has been much reduced. The type specimens themselves have been fully described by the writer in the "American Journal of Science."

Restoration of Anchisaurus.

The Triassic dinosaurs now known from the Connecticut river sandstone have been investigated by the writer, and some of the results have already been placed on record.[1] Remains of five individuals have been discovered, sufficiently well preserved to indicate the main characters of the animals to which they pertained. These were all carnivorous forms of moderate size, and the known remains are from essentially the same geological horizon. Many larger forms, probably herbivorous, are indicated by footprints, but no characteristic portions of the skeleton have yet been found.

The genus *Anchisaurus*, one of the oldest known members of the *Theropoda*, is so well represented by parts of four skeletons, two nearly complete, from these deposits, that a restoration of one species can now be made with considerable certainty. This has been attempted, and the result is given, one-twelfth natural size, in the above figure (Fig. 1). The animal when alive was about six feet in length.

The skeleton chosen for this restoration is the type specimen of *Anchisaurus colurus*, already described by the writer. This skeleton when discovered was apparently entire. Portions of the neck and the tail vertebræ were unfortunately lost before the importance of the specimen was realized, but the skull, and nearly all the rest of the skeleton, were saved. From these the matrix in great part has been removed, so that the more important characters can be made out with certainty. The parts missing are fortunately preserved in a smaller specimen of an allied species (*Anchisaurus solus*) found at the same locality, and these have been used to complete the outline of the restoration. Portions of two other specimens, nearly allied, and from the same horizon, were also available, and furnished some suggestions of value.

The restoration as shown in Fig. 1. indicates that *Anchisaurus colurus* was one of the most slender and delicate dinosaurs yet discovered, being only surpassed in this respect by some of the smaller bird-like forms of the Jurassic. The position chosen is one that must have been habitually assumed by the animal during life, but the comparatively large fore limbs suggest the possibility of motion on all four feet. The compressed terminal digits of the fore feet, however, must have been covered by very sharp claws, which were used mainly for prehension, and not for locomotion.

The small head and bird-like neck are especially noticeable. The ribs of the neck and trunk are very slender. The tail apparently differed from that of any other dinosaur hitherto described, as it was

[1] American Journal of Science, vol. xxxvii. p. 331, April, 1889; vol. xlii. p. 267, September, 1891; and vol. xliii. p. 543, June, 1892; see also vol. xlv. p. 171, February, 1893.

evidently quite slender and flexible. The short neural spines and the diminutive chevrons directed backward indicate a tail not compressed, but nearly round, and one usually carried free from the ground.

The type specimen of *Anchisaurus*, here restored, was found in Connecticut, in the upper portion of the Triassic sandstone. The associated fossils were carnivorous dinosaurs and plants.

The present restoration will tend to clear up one point long in doubt. The so-called "bird-tracks" of the Connecticut river sandstone have been a fruitful subject of discussion for half a century or more. That some of these were not made by birds has already been clearly demonstrated by finding with them the impressions of fore feet, similar to those made by reptiles. Although no osseous remains were found with them, others have been regarded as footprints of birds, because it was supposed that birds alone could make such series of bipedal, three-toed tracks, and leave no impression of a tail.

It is now evident, however, that a dinosaurian reptile like *Anchisaurus* and its near allies must have made footprints very similar to, if not identical with, the "bird tracks" of this horizon. On a firm but moist beach, only three-toed impressions would have been left by the hind feet, and the tail could have been kept free from the ground. On a soft, muddy shore, the claw of the first digit of the hind foot would have left its mark, and perhaps the tail also would have touched the ground. Such additional impressions the writer has observed in various series of typical "bird tracks" in the Connecticut sandstone, and all of them were probably made by dinosaurian reptiles. No tracks of true birds are known in this horizon.

Restoration of Ceratosaurus.. (Plate VI.)

In the same horizon of the Jurassic in which *Brontosaurus* and *Stegosaurus* were found, the skeleton restored in Plate VI. was likewise discovered. It pertained to a typical carnivorous dinosaur of medium size, which doubtless was one of the various enemies of the large herbivorous forms. The restoration represents the reptile one-thirtieth natural size, and in a position it must have frequently assumed in life. The type-specimen on which this restoration is based has already been described by the writer.[1]

The skull of *Ceratosaurus* is very large in proportion to the rest of the skeleton. The posterior region is elevated, and moderately expanded transversely. The facial portion is elongate, and tapers gradually to the muzzle. Seen from above, the skull resembles in general outline that of a crocodile. The nasal openings are separate and lateral, and are placed near the end of the snout, as shown in Plate VI.

Seen from the side, this skull appears lacertilian in type, the general structure being light and open. From this point of view, one special feature is the large, elevated, trenchant horn-core situated

[1] American Journal of Science, vol. xxvii. p. 329, April, 1884; vol. xxviii. p. 161, August, 1884; and vol. xliv. p. 347, October, 1892.

on the nasals. Another feature is the large openings on the side of the skull, four in number. The first of these is the anterior nasal orifice; the second, the triangular antorbital foramen; the third, the large oval orbit; and the fourth, the still larger lower temporal opening.

The parietal bones are of moderate size, and there is no parietal foramen. The frontal bones are rather short, and are closely united on the median line. The nasal bones are more elongate than the frontals, and are firmly coössified. These bones support the compressed, elevated horn-core on the median line. The lateral surface of this elevation is very rugose, and furrowed with vascular grooves. It evidently supported a high trenchant horn, which must have formed a most powerful weapon for offence and defence.

The premaxillaries are separate, and each contained three functional teeth. The maxillary bones are large and massive, as shown in Plate VI. They are provided each with fifteen functional teeth, which are large, powerful, and trenchant, indicating the ferocious character of the animal when alive. These teeth have the same general form as those of *Megalosaurus*, and the dental succession appears to be quite the same. Above the antorbital foramen on either side is a high elevation composed of the prefrontal bones. These protuberances would be of service in protecting the orbit, which they partially overhang.

The lower jaws of *Ceratosaurus* are large and powerful, especially in the posterior part. In front, the rami are much compressed, and they were joined together by cartilage only. There were fifteen teeth in each ramus, similar in form to those of the upper jaws.

The cervical vertebræ of *Ceratosaurus* differ in type from those in any other known reptiles. With the exception of the atlas, all are strongly opisthocœlian, the cup on the posterior end of each centrum being unusually deep. In place of an equally developed ball on the anterior end, there is a flat surface. The size of the latter is such that it can only be inserted a short distance in the adjoining cup. This peculiar articulation leaves more than three-fourths of the cup unoccupied by the succeeding vertebra, forming, apparently, a weak joint.

The dorsal and lumbar vertebræ are bi-concave, with only moderate concavities. The sides and lower surface of the centra are deeply excavated, except at the ends. All the pre-sacral vertebræ are very hollow, and this is also true of the anterior caudals.

There are five well-coössified vertebræ in the sacrum of the present specimen of *Ceratosaurus nasicornis*. The transverse processes are very short, each supported by two vertebræ, and they do not meet at their distal ends. The caudal vertebræ are bi-concave. All the anterior caudals, except the first, supported very long chevrons, indicating a high, thin tail, well adapted to swimming. The tail was quite long, and the distal caudals were very short.

The scapular arch of *Ceratosaurus* is of moderate size, but the fore limbs are very small. The humerus is short, with a strong radial crest. The radius and ulna are also very short, and nearly equal

in size. The carpal bones were only imperfectly ossified. There were four digits in the fore foot, and all were armed with sharp claws. The second and third digits were much larger than the first and fourth, and the fifth was entirely wanting.

The pelvic arch of *Ceratosaurus* is of special interest. In the type specimen here restored, the ilium, ischium, and pubis, on each side, are firmly coössified. The ilia, moreover, are attached to the sacrum, which was in place in the skeleton. The ilia have the same general form as in *Megalosaurus*. The ischia are comparatively slender. They project well backward, and for the last half of their length the two are in close apposition. Their distal ends are coössified and expanded, as shown in Plate VI.

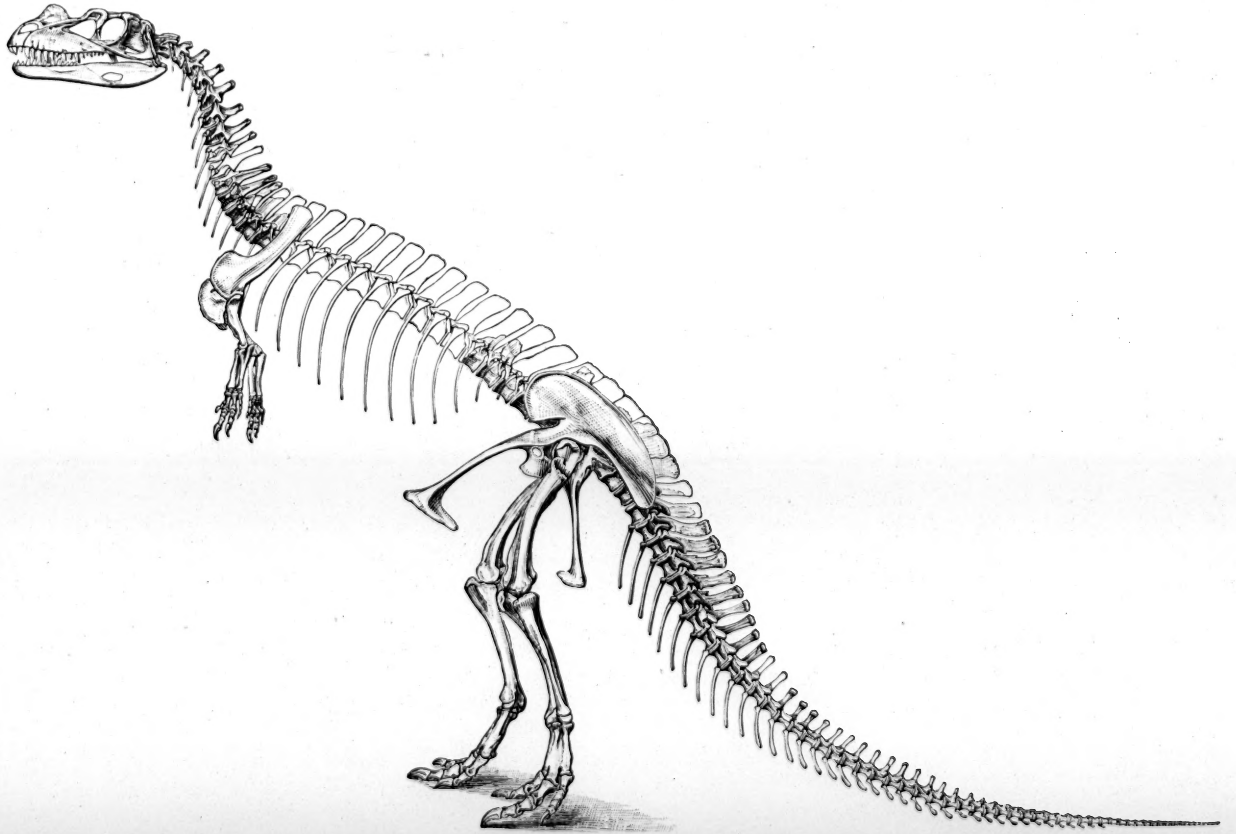
The pubes have their distal ends coössified, and expand into an elongate, massive foot, which is one of the most characteristic parts of the skeleton. It is probable that this foot in connection with the distal ends of the ischia served to support the body in sitting down. That some Triassic dinosaurs sat down on their ischia is proved conclusively by the impressions in the Connecticut river sandstone. In such cases, the leg was bent so as to bring the heel to the ground. The same action in the present reptile would bring the foot of the pubes to the ground, nearly or quite under the centre of gravity of the animal. The legs and ischia would then naturally aid in keeping the body balanced. Possibly this position was assumed habitually by these ferocious biped reptiles, in lying in wait for their prey.

The femur is much curved, and the shaft very hollow. The tibia is shorter than the femur, nearly straight, and has a large cnemial crest. The astragalus is not coössified with the tibia, and has a strong ascending process. The fibula is well developed, and nearly straight, its distal end fitting into the calcaneum. The tarsals of the second row are very thin, and united to the metatarsals below them.

The most interesting feature in the extremities of this dinosaur is in the metatarsal bones, which are completely ankylosed, as are the bones of the pelvis. There are only three metatarsal elements in each foot, the first and fifth having apparently disappeared entirely. The three metatarsals remaining, which are the second, third, and fourth, are proportionally shorter and more robust than in the other known members of the *Theropoda*, and being firmly united to each other, they furnish the basis for a very strong hind foot. The phalanges of the hind feet are of moderate length, and most of them are quite hollow. The terminal phalanges evidently supported strong and sharp claws.

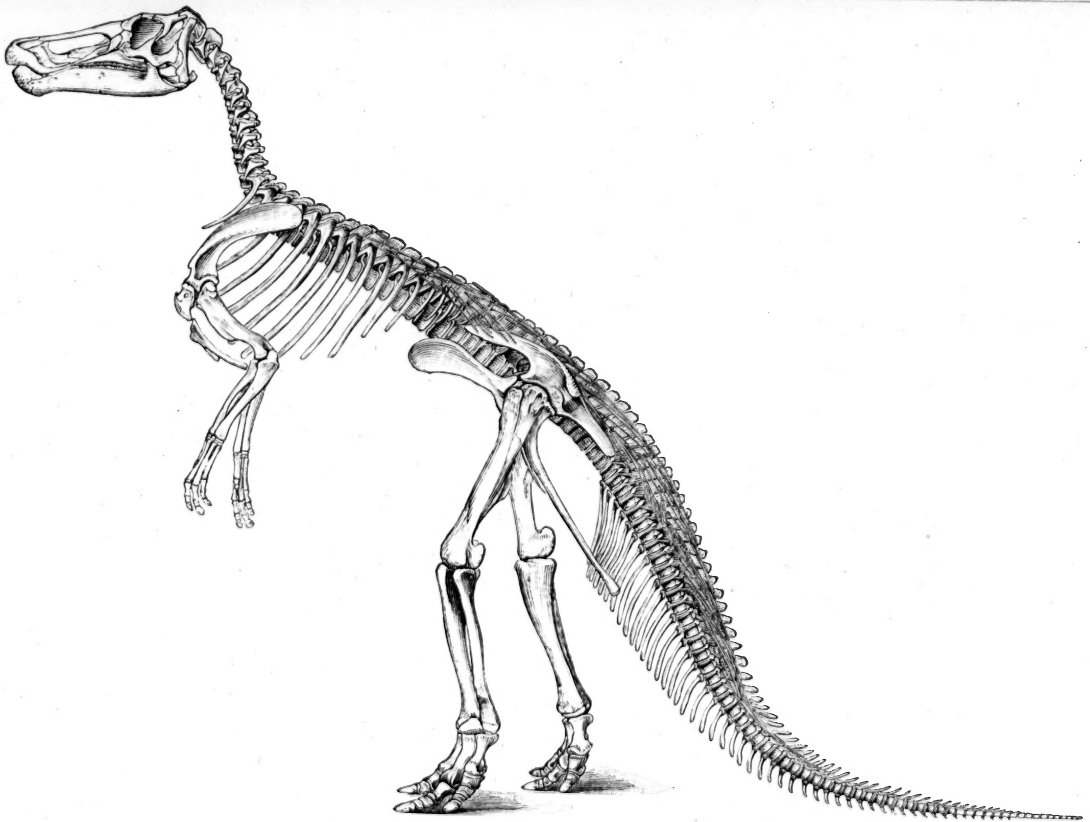
The unique cervical vertebræ, the coössification of the pelvic bones, and the union of the metatarsals, as in modern birds, distinguish *Ceratosaurus* widely from all other dinosaurs, and make it the type of a well-marked family, the *Ceratosauridæ*. The nearest allied form is apparently *Ornithomimus*, from the Laramie, recently described by the writer.

The type specimen of *Ceratosaurus* was about twenty-two feet long when alive, and twelve feet high as here restored. It was



Ceratosaurus nasicornis, Marsh. $\frac{1}{30}$ nat. size.

UPPER JURASSIC, COLORADO.



Clavsaurus annectens, Marsh. $\frac{1}{10}$ nat. size.

found in the upper Jurassic of Colorado. The associated fossils were mainly other dinosaurs, especially *Sauropoda* and *Ornithopoda*, together with various small mammals.

Restoration of Claosaurus. (Plate VII.)

The most interesting feature in the restoration of *Claosaurus* given on Plate VII. is the skull, which has been fully described by the writer elsewhere,[1] but its main features may be noticed here. This skull is long and narrow, with the facial portion especially produced. The anterior part is only moderately expanded transversely, thus differing from that of *Hadrosaurus*, a nearly allied form. Seen from the side, the skull of *Claosaurus* shows a blunt, rugose muzzle, formed above by the premaxillary, and below by the predentary, both probably covered in life with a thick corneous integument.

Behind the upper part of this muzzle is an enormous lateral cavity, which includes the narial orifice, but was evidently occupied in life mainly by a nasal gland, somewhat like that in the existing Monitor, and also seen in some Birds. This cavity is bounded externally by the nasal bone and the premaxillary. The orbit is very large, and subtriangular in outline. It is formed above by the prefrontal, frontal, and postfrontal, and below mainly by the jugal. There are no supra-orbital bones. A distinct lachrymal forms a portion of the anterior border. The infra-temporal fossa is large, and bounded below by the jugal. There is a thin quadrato-jugal between the jugal and quadrate. The occipital condyle is directed backward and downward.

The nasals are very long and slender, and in front are separated by the narrow superior processes of the premaxillaries. The frontals are short and broad, and somewhat concave above. The parietals are firmly coössified, and very small, forming a thin partition between the supra-temporal fossæ. The latter are bounded posteriorly by the massive squamosals, which contain a deep cavity for the head of the quadrate, and also overlap the exoccipitals.

The striking features of the lower jaw are the massive rugose predentary, the large and powerful dentary bone with its robust coronoid process, and the very small angular and articular bones.

The teeth are confined entirely to the maxillary and dentary bones. They closely resemble those of *Hadrosaurus*, are arranged in the same manner, and appear to be equally numerous. They were well adapted to a diet of soft succulent vegetation.

The main characters of the vertebral column of *Claosaurus* are shown in the restoration. There are thirty vertebræ between the skull and sacrum, nine in the sacrum, and about sixty in the tail. The whole vertebral column was found in position except the terminal caudals, which are here represented in outline. The cervical vertebræ are strongly opisthocœlian, and the first eleven have short ribs. The dorsals are also opisthocœlian. There are no true lumbar vertebræ, as the last of those in front of the sacrum support free

[1] American Journal of Science, vol. xxxix. p. 423, May, 1890; vol. xliii. p. 453, May, 1892; vol. xliv. p. 171, August, 1892; and vol. xliv. p. 344, October, 1892.

ribs. The first and second caudals have no chevrons. Behind these, thec hevron bones are very long, indicating a powerful compressed tail, well adapted for swimming.

In the median dorsal region, between the ribs and the neural spines, are numerous rod-like ossified tendons, which increase in number in the sacral region and along the base of the tail, and then gradually diminish in number and size, ending at about the thirty-fifth caudal. These ossified tendons are well shown in the restoration, and are of much interest. They are not unlike those in *Iguanodon* described by Dollo, but as a rule are more elongate, and appear to lack the definite arrangement in rhomboidal figures observed in that genus.

The fore limbs are unusually small in comparison with the posterior, and the relative size of the two is shown in the restoration. The scapular arch presents many points of interest. The scapular is large, and much curved. On the anterior margin, above the articulation for the coracoid, is a strong protuberance, with a well-defined facet, adapted to the support of a clavicle, if such a bone were present. The coracoid is very small, and is perforated by a large foramen. The two peculiar bones now generally regarded as belonging to the sternum were not coössified.

The humerus is comparatively short. The radius and ulna are much elongated, the latter being longer than the humerus, and the radius about the same length. The ulna has a prominent olecranon process, and is a stouter bone than the radius. The carpal bones were quite short, and appear to have been only imperfectly ossified. The fore foot, or manus, was very long, and contained three functional digits only. The first digit was rudimentary, the second and third were nearly equal in length, the fourth was shorter and less developed, and the fifth entirely wanting, as shown in Plate VII.

In the functional digits (Plates II. III. IV.), the phalanges are elongate, thus materially lengthening the fore foot. The terminal phalanges of these digits are broad and flat, showing that they were covered with hoofs, and not with claws. The limb as a whole was thus adapted to locomotion or support, and not at all for prehension, although this might have been expected from its small size and position.

The elongation of the fore-arm and manus is a peculiar feature, especially when taken in connection with the ungulate phalanges. It may, perhaps, be explained by supposing that the animal gradually assumed a more erect position until it became essentially a biped, while the fore limbs retained in a measure their primitive function, and did not become prehensile, as was the case in some allied forms.

The pelvis has already been described by the writer. Its most notable features are seen in the pubis and ischium, the former having a very large expanded prepubis with the postpubis rudimentary, while the shaft of the ischium is greatly elongated.

The femur is long, and the shaft nearly straight. The great trochanter is well developed, while the third trochanter is large and near the middle of the shaft. The external condyle of the distal

end is projected well backward, indicating great freedom of motion at the knee.

The tibia is shorter than the femur, and has a prominent cnemial crest. The distal end is much flattened, and the astragalus is closely adapted to it. The fibula is very straight, with its lower end flattened and closely applied to the front of the tibia. The calcaneum is large, with its concave upper surface closely fitted to the end of the fibula. Of the second row of tarsals, only a single one appears to be ossified, and that is very small and thin, and placed between the calcaneum and the fourth metatarsal, nearly or quite out of sight.

The hind foot, or pes, had but three digits, the second, third, and fourth, all well developed and massive. The terminal phalanges were covered with broad hoofs. The first and fifth digits were entirely wanting.

The reptile here restored was nearly thirty feet in length when alive, and about fifteen in height in the position represented in Plate VII. The remains were obtained in the Laramie of Wyoming. Among the associated fossils were the gigantic *Triceratops* and *Torosaurus*, herbivorous dinosaurs, and with them the diminutive Cretaceous mammals recently described by the writer.

III.—On the Occurrence of Concretionary Masses of Flint and Chert in the Maltese Limestones.

By John H. Cooke, F.G.S., etc.

THE late Admiral Spratt, R.N.,[1] and Dr. John Murray,[2] of the "Challenger" Expedition, have, in their brochures on Maltese Geology, made allusion *en passant* to the occurrence of chert nodules in the *Globigerina* limestones of the Maltese islands. Neither of these gentlemen, however, gave any details of the nature, mode of occurrence, or distribution of the concretions, an omission which was probably due to the restricted area of the horizon at which the nodules are found, and to the irregular and sparse manner in which they are distributed.

The following notes on these points, which were collected in the course of my geological investigations into the fauna of the formation, may not, therefore, be without some value to present and future students of Maltese geology.

The *Globigerina* limestones in which the concretions occur occupy the second place in the ascending order of the Maltese formations. They attain a maximum thickness of about 250 feet, and comprise a series of layers or beds which vary in number in different localities from four to ten. Between the beds themselves the variations are but slight, and are of a chemical rather than of a lithological or a palæontological character, consisting generally of a greater or lesser percentage of carbonate of lime according to the

[1] "This deposit often contains nodules of a flinty texture, viz., chert, in which are fish-scales." The Geology of Malta and Gozo. Malta, 1854, p. 7.

[2] "Nodules of flint and chert are found in some of the layers." "The Maltese Islands, with special reference to their geological structure." Scot. Geog. Mag., September, 1890, p. 24.

extent to which the beds were influenced by the river-waters which brought down detrital products from the surrounding continental areas.

The following table shows the relative positions, and the more prominent characteristics of the sub-divisions.

Formation.	Sub-divisions.	Thickness.
Globigerina Limestone.	*a*. A greyish, fine-grained freestone.	15 to 20 feet.
	b. First seam of phosphatic nodules.	1 foot.
	c. A whitish, compact, fine-grained freestone.	40 to 50 feet.
	d. Second seam of phosphatic nodules.	1 to 2 feet.
	e. A soft blue limestone with phosphatic nodules irregularly distributed throughout it.	50 feet.
	f. A white, highly calcareous limestone with flint and chert nodules.	30 to 50 feet.
	g. A coarse-grained yellowish freestone.	20 to 40 feet.
	h. Fourth seam of phosphatic nodules.	2 to 4 feet.

It would be irrelevant to here consider these beds in detail; I shall, therefore, simply regard the formation as being broadly divisible into three sections, *i.e.*

a. Deposits containing from 30 per cent. to 80 per cent. of carbonate of lime; the residue being principally made up of alumina with a small quantity of silica. Dr. John Murray considers this portion of the bed to have been formed on a descending sea-floor in about 300 fathoms of water, and to have been within the influence of river-waters and their detrital products.

b. Deposits containing from 80 to 90 per cent. of carbonate of lime. Probably deposited in about 1000 fathoms of water.

c. Deposits containing 70 per cent. and less of carbonate of lime; and consisting for the most part of the remains of comparatively shallow-water organisms. These were laid down on a rising sea-floor, and in about 300 fathoms.

The *Globigerina* limestones may, therefore, be considered as being a series of deposits laid down during a gradual but constant change in the position of the sea-bottom, the deposits in division *b*. having been formed about the time when the maximum depression was being attained, and at a considerable distance from any shore-line.

In the lower parts of this intermediate division considerable quantities of siliceous concretions are found to occur in certain localities, of which the cliffs at Fommer Rih, the escarpments around the slopes of Uied Mars-el-Forn, Uied Sakkaja, and Uied Hempsia, and the quarries of Tad-dual, Tal Gauchi, and Inghieret furnish some of the most characteristic specimens. In none of the more impure varieties of limestone in either the upper or the lower divisions have any specimens been found.

The concretions assume a variety of forms occurring sometimes as irregularly shaped masses of two or more feet in length, and from six to twelve inches in thickness, or as spheroidally shaped

nodules having more or less symmetrically shaped outlines. In composition they also vary greatly, the larger masses being composed of flint (silex), while the smaller nodular forms consist of chert (phtanite), which is an impure calcareous variety of flint.

At Fommer Rih and along the hill-slopes already referred to, the differential degradation to which the nodular masses and their matrices have been subjected has resulted in the complete isolation of the former, and they have thus been caused to project from the faces of the cliffs and escarpments as bold conical bosses.

In none of the nodules are these exposed portions entire, as all of them have been more or less acted upon by the same meteoric agencies that have removed the limestone from around them.

In many instances the disintegration has proceeded by the peeling off of laminated scales, while in others small shapeless masses have broken away and left the weathered surfaces irregularly prismatic in character.

Viewed with the naked eye both the nodules and the larger masses are exceedingly homogeneous; but when examined under a low magnifying power, sections of foraminifera, small molluscs, and other organisms are to be seen embedded.

In none of the specimens that I have examined have I observed any of the fish-scales to which Spratt alluded in his brochure; but I cannot venture to say that, therefore, such remains are either absent or of rare occurrence.

In colour both the flint and the chert vary widely, graduating through all the intermediate shades of grey, fawn, blue, and black.

The interiors of the nodules are generally of a jet black colour, a fact which is probably due to the presence of carbonaceous matter, as much of it disappeared when subjected to the action of the blow-pipe flame. This black interior often graduates into a semi-translucent grey towards the outer edges, thus causing the concretions when cut transversely to present the appearance of being made up of a series of concentric layers of varying hues; such specimens are not, however, so common as are the uniformly black, grey, and fawn coloured varieties.

The limestone surrounding the masses and the nodules is invariably changed into chert more or less pure in character. This cherty limestone is often of a colour similar to that of the enclosed nodule, and unless carefully examined it is often difficult to say where the line of demarcation between the two lies.

The former, however, is neither so compact nor does it present, when broken by means of a smart blow with a hammer, the conchoidal fracture which is so characteristic of the latter.

From the similarity which exists between the characters of these flints and cherts and those which occur so plentifully in other limestone formations, it seems probable that the origins of both are to be traced to analogous causes.

The Maltese varieties are found only in the most highly calcareous portions of the strata, embedded among the *Globigerinæ* of which the greater part of the formation is made up.

It was probably to the action of these and other organisms in eliminating the silica held in solution in the sea-water, and afterwards to chemical action, whereby further precipitation of silica on and around that which had been previously secreted by the organisms, that these nodular masses had their origin.

IV.—Analysis of the Fullers Earth of Vrongoch.

By P. Gerald Sanford, F.I.C., F.C.S.

SOME four years ago I published in this Magazine[1] an analysis of the Fullers Earth of Nutfield, Surrey. The Nutfield samples were given to me by A. Sheridan, Esq., C.E. I now wish to record the analysis of a large bed of this clay at Rhiwlas, Vrongoch, near Bala, N. Wales. The beds are about 60 feet thick, and are upon the property of R. J. Lloyd Price, Esq. In this case also, the samples were sent to me by Mr. Sheridan. The two samples A and B are of somewhat different composition. B contains considerably more silicate of alumina and less alumina than A. A would of course, from a fuller's point of view, be the better earth of the two. Although the Nutfield and Vrongoch earths are so similar in composition, their appearance is very different: the Surrey earth has a greasy feel, a hard smooth surface, that can only just be scratched with the finger nail; the Vrongoch earth is soft and friable, dark grey in colour, and very earthy, and dissolves in water to the extent of about 4 per cent. of its weight. As regards the grease absorbing properties, the Vrongoch earth appears to be even better than the Nutfield samples. Fullers Earth appears to be an excellent material for cleaning chemical apparatus that is greasy, or soiled with fats and oils.

Analysis No. 1.—Sample A.

Matter insoluble in acid	= 78·27	per cent. consisting of	Silica	= 63·25 p.c.
Alumina (Al_2O_3)	= 12·95	,,	Fe_2O_3	= 8·72 ,,
Peroxide of iron (Fe_2O_3)	= 0·42	,,	Al_2O_3	= 6·30 ,,
Lime (CaO)	= 0·82	,,		78·27
Manganese oxide	= trace			
Magnesia (MgO)	= 1·65	,,		
Sulphuric acid (SO_3)	= 0·31	,,		
Alkalies (K_2O, Na_2O)	= 2·02	,,		
Combined water	= 3·56	,,		
	100·00			

Analysis No. 2.—Sample B.

Matter insoluble in acid	= 78·53	p. c. consisting of	Silica	= 57·01 p.c.
Alumina	= 2·84	,,	Fe_2O_3	= trace
Peroxide of iron ...	= 8·50	,,	Al_2O_3	= 21·52 p.c.
Lime	= 0·90	,,		78·53
Manganese oxide ...	= trace			
Magnesia	= 2·30	,,		
Sulphuric acid ...	= 0·05	,,		
Alkalies	= 2·12	,,		
Combined water ...	= 4·76	,,		
	100·00			

[1] Geol. Mag. Decade III. Vol. VI. No. 301, p. 455.

V.—The True Horizon of the Mammoth.

By Sir Henry H. Howorth, K.C.I.E., M.P., F.S.A., F.G.S.

I AM highly gratified that some of the difficult problems connected with the Mammoth and its surroundings, which have been too long ignored, are at last attracting something like adequate attention; and I regret that Mr. Jukes-Browne should withdraw from the controversy without, as it seems to me, doing justice to the cause he represents. In his concluding letter he adds nothing but a reference to Mr. Clement Reid and Mr. Horace B. Woodward, neither of whom need a vicarious spokesman. I wish he had been able to point to one well attested example to prove his case. I must again press upon him the fact that mere rhetoric is of no avail in this or any other scientific discussion. What we need is to be pointed to some example within our four seas of the occurrence of a land-surface dating from the Mammoth period underlaid by true drift.

I will now turn to Mr. Stirrup, who, while indulging in some amusing dogmatism, does favour us with some arguments. These arguments I will endeavour to meet. First in regard to Switzerland. Here I confess I cannot quite follow him. He does not traverse the statements of the chain of witnesses whom I quoted who have examined the beds at Dürnten and Utznach, including Sir Charles Lyell and Heer himself, and who came to the conclusion that the Mammalian beds there are under and not over the drift; but he apparently thinks he answers the virtually unanimous stratigraphical testimony by asking me if I think the Mammoth, the *Elephas antiquus*, the *Urus*, and the Red Stag lived together in Switzerland before the Glacial period. I certainly think they lived there before the distribution of the drift; just as they did in England at the time when the brick-earths of the Thames Valley were being deposited. This I have argued at considerable length in my big book on the Mammoth. All the authorities known to me place these Zurich beds on the same horizon as the Forest-bed of Norfolk. Is there anybody anywhere who puts the Forest-bed of Norfolk above and not under the Drift? I think Mr. Stirrup should explain himself rather more definitely.

Let us now turn to another part of Mr. Stirrup's communication to which he devotes a considerable space, but the relevancy of which I am at a loss to understand: I mean what he has to say in reference to the well known journey of Baron Toll and Herr Bunge to the Bear Islands. Mr. Stirrup does not seem to be aware that although the detailed scientific work of the expedition is only in course of publication, an interesting work giving an account of their journey has been published for some time and is naturally familiar to those who take an interest in the history of the Mammoth.

What possible support Mr. Stirrup can find for his contention in the work of the two Russian explorers I quite fail to see. The fact of beds of ice underlying the Tundra deposits of North-Eastern Russia and of Siberia has been known for a century. That the

Mammoth carcases are not found in this ice but in frozen gravel and mud has also been known for a long time, and the whole question is discussed at some length in a part of my Mammoth book, which Mr. Stirrup might, I think, have profitably consulted.

That the ice in question is palæocrystic ice dating from Pleistocene times is no doubt a new suggestion, at least, as far as I know, but what evidence there is of this I altogether fail to see. Those who have hitherto written on the subject have explained these ice-beds very rationally. The ground in Northern Siberia is permanently frozen at a depth of a few feet from the surface. The stratum thus frozen prevents a complete drainage of the surface water, which, percolating through the ground, reaches the frozen layer cannot get away and presently becomes itself frozen. Thus a thin bed of ice is formed which gradually grows in thickness between the permanently frozen subsoil and that part of it which is thawed every year. This is the natural consequence of the present climate of Siberia. When the Mammoth and its companions lived there and lived, as I think I have elsewhere proved, as far north as the Bear Islands, the climate must have been very different. Not only was the country covered with forests but the land-shells which have been found with the remains of these forests with Mammoth bones, are incompatible with the existence during the Mammoth age of permanently frozen soil in Siberia. This I have urged at some length in the book already quoted. It is for Mr. Stirrup, who has apparently applied himself to these problems for the first time quite recently, to face this dilemma; I think he ought to have faced it before he used flippant phrases about such a master of observation and logic as Cuvier. I am bound to say I cannot see that he has in the slightest degree qualified the conclusion of the great French philosopher and naturalist, a conclusion endorsed in more recent times by two such authorities as D'Archiac and De Lapparent.

Turning to the researches of M. Tchernyschew, I am equally at a loss to know what conclusion Mr. Stirrup would base them upon. That the Tundras of North-Eastern Europe and of Siberia are underlaid by gravels, is a very elementary fact; they have been described by several explorers and notably by Middendorff and Schmidt. These gravels consist of water-rolled local pebbles, some of which are doubtless scratched as they are in all gravels, but so far as the evidence before me, and it is very considerable, goes, there is not a trace in them of *erratics*, of boulders with flat sides and of the other real footmarks of glacial action; nay, more, the experienced geologists like Nordenskiold, Von Cotta, and others, who have carefully examined this very problem on the ground, are agreed that no traces of an Ice Age, except the one in progress now exist in Siberia, neither in the mountains nor in the plains. Here, again Mr. Stirrup has surely, like the Spanish Knight, been tilting at a windmill.

Again, he bids me remember that in America the Mammoth and the Mastodon occur in the superficial deposits. Of course they do, but what has this to do with the question. There are many places within easy reach of Manchester where mountain limestone shells

occur at the surface. Does this prove that the mountain limestone is more recent than the so-called glacial beds? The fact is we can follow the Mammoth beds from Europe right across Asia, and when we cross Behring's Straits we find them again under precisely the same conditions in Alaska, and we can follow them in detached fragments right down to Ohio and further, and whether we find the bones in the North of Russia, in Siberia, in Alaska, or in the Salt Swamps of Ohio, their contemporaneity seems established. What we want evidence of is, not the distance at which a Mastodon skeleton has been found from the surface, that is immaterial, but whether it lies upon *true* drift or not.

I do not dispute that occasional molars of Mammoth, etc., occur in the Drift. Every casual student has found many kinds of early fossils in that formation, which are merely boulders. What we need is not the production of samples of these bone-boulders or of detached logs of wood, but as Dr. Hicks says, evidence of an actual land-surface with Mammoth remains in it, planted over and not under the Drift.

That Man and the Mammoth have occurred together in caverns is a perfectly elementary fact. They have similarly occurred in the loess; but what has this to do with the question. That palæolithic man was pre-Glacial in the sense in which the word is generally used, that is to say, that he lived before the widespread distribution of the Drift? I have no doubt about myself. May I ask Mr. Stirrup, however, to explain what he means by saying that the Lehm *is uniformly spread over the ancient or glacial alluviums* and that it *certainly belongs to the closing phases of the Ice-Age.* I should like to see some evidence of this besides a mere *obiter dictum.* To my mind if there is a deposit anywhere which is a flood deposit and not a glacial deposit it is that curious calcareous loam which in China, in the United States, and in Central Europe is called Loess or Lehm; which in South America is called Pampas mud; and which in Russia is called Chernozem. That it contains scattered bones and shells of land mollusks is true enough. It is no less true, as it seems to me, that it was deposited after and not before the Mammoth age, and that the Mammoth and the human bones and the land-shells in it were derived from the pre-existing land-surface.

I have now examined every argument and every fact adduced by Mr. Stirrup except his references to Falsan and Favre. These you will allow me to criticize on another occasion. Apart from them it would seem that the case for the foreign existence of a post-Glacial Mammoth, as presented by Mr. Stirrup, fails as completely as the English case, presented by Mr. Jukes-Browne, does.

On such a critical matter as the true horizon of the Mammoth on which so much strong and dogmatic language has been used by those who champion its post-Glacial survival, it is surely not unreasonable to ask for the production of a single case which will bear examination and criticism to support the contention. Geology is, or ought to be, an inductive science and not a survival of mediæval scholasticism.

VI.—Restoration of *Mastodon Americanus*, Cuvier.

By Professor O. C. Marsh. M.A., Ph.D., LL.D., F.G.S., Etc.

(PLATE VIII.)

THE great abundance and good preservation of the remains of the American *Mastodon* have led to various restorations of the skeleton. The best known of these is that made by Prof. Richard Owen, in 1846, based upon a skeleton from Missouri, now in the British Museum.[1] Another restoration was made a few years later by Dr. J. C. Warren, based mainly on a very perfect skeleton from Orange county, New York.[2] This skeleton is now preserved in the Warren Museum in Boston. A third restoration was made by Prof. James Hall, from a skeleton found at Cohoes, New York, and now in the State Museum of Natural History, in Albany.[3] These restorations are all of importance, and taken together have made clear to anatomists nearly all the essential features of the skeleton of this well-known species.

Additional discoveries have since brought to light more perfect specimens, one of which, now in the Yale Museum, is perhaps in the best preservation of any skeleton of the American *Mastodon* yet discovered, and this has been used by the writer in the restoration, one thirty-second natural size, given on Plate VIII.

The position chosen in this restoration is one which seems especially fitted to bring out the massive proportions of the animal, and, at the same time, to show nearly all the characteristic features of the entire skeleton. The animal, as thus represented was, when alive, about twelve feet in height, and perhaps twenty-four feet in length including the tusks.

This animal was fully adult, as the last molars above and below are in place and somewhat worn. The epiphyses of the vertebræ, moreover, are nearly all coössified with the centra, and in some of them, the sutures are obliterated. The epiphyses are also firmly united to the limb bones.

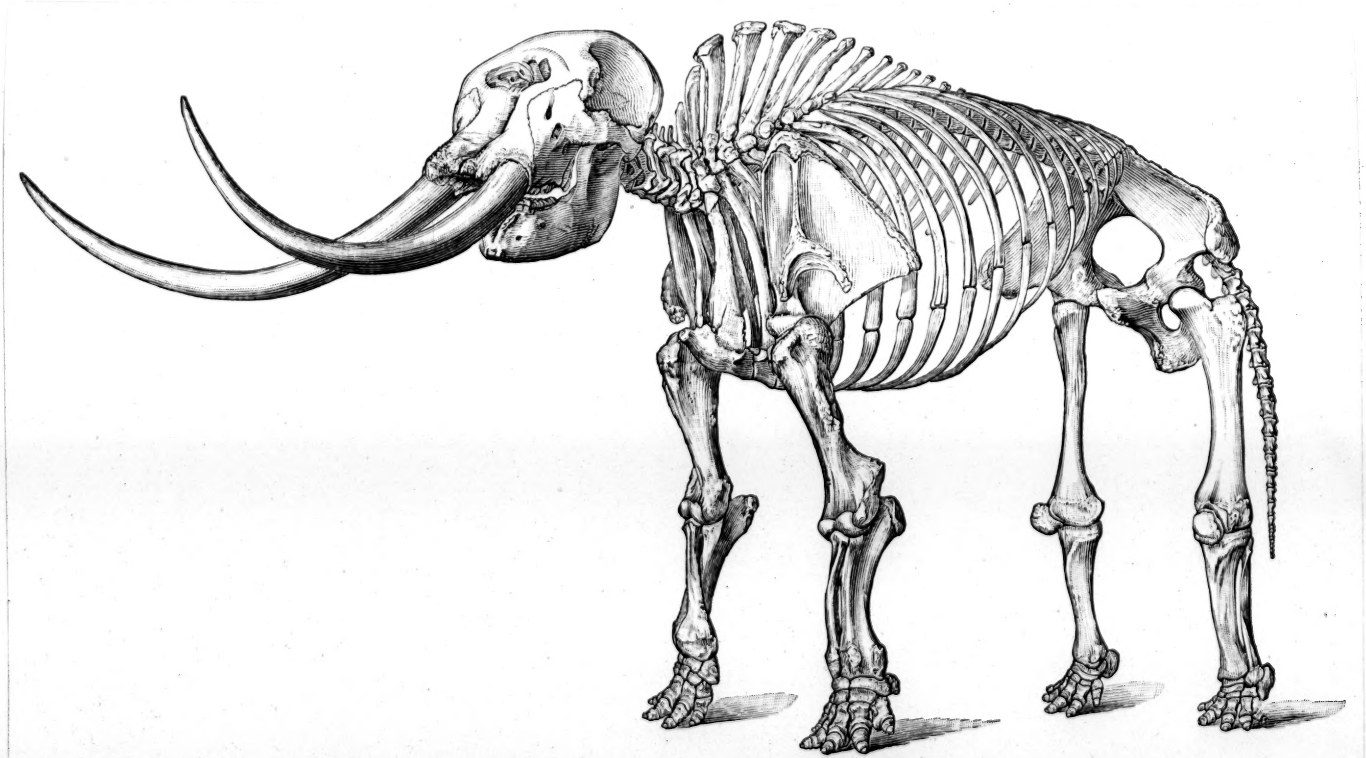
The tusks were very large, and considerably divergent. There were no inferior tusks, and no traces of their alveoli remain. The penultimate and last molars are present above and below in fine preservation, the former considerably worn.

Other features of this skeleton, and especially the various new anatomical points it discloses, will be discussed by the writer elsewhere.

[1] British fossil Mammals and Birds, fig. 102, p. 298, London, 1846.

[2] Description of a skeleton of the *Mastodon giganteus* of North America, pl. xxvii. Boston, 1852.

[3] Report of the New York State Cabinet of Natural History for the year 1867, plate vi. Albany, 1871.



Mastodon Americanus, Cuvier. $\frac{1}{32}$ nat size.

NOTICES OF MEMOIRS.

I.—How the Waters of the Ocean became Salt.[1] By Prof. Edward Hull, LL.D., F.R.S., F.G.S.

THERE are many things in the world around us to which we are so accustomed from childhood that we never stop to enquire why they should be so. That rivers and lakes should consist of fresh water, and that the sea should be formed of salt water, seems so natural that we consider them as not only matters of course, but essential to the physical economy of the world; and if perchance our attention is called to the fact that some inland lakes are formed of salt water we proceed to investigate the cause of so unusual an occurrence—one which being exceptional requires special explanation. But how few of the thousands and millions who traverse the ocean or dwell upon its shores put to themselves the question "Why are its waters salt?" And this, notwithstanding that it is daily receiving supplies of fresh water both from the rain which falls upon its surface and from the rivers which empty themselves into it. Clearly there is something here which *does* require special investigation, a question which *does* need solution, because, as far as the supplies afforded by the rain and rivers are concerned, the ocean waters ought apparently to be fresh rather than salt.

2. In using the terms "fresh" and "salt" here, and in the following pages, I do so in the popular sense of the words. Scarcely any natural water, except rain, is absolutely free from dissolved salts. All rivers contain them to a greater or less extent, as do also the waters derived from wells and springs. Such waters, however, are called (and properly called) "fresh," which does not necessarily mean water absolutely devoid of salts in solution; but when the proportion of salts is so great as to cause the water in which they are dissolved to appear "salt" to the taste, then the term salt water or brine is applied to them. The varieties of saline waters and the degrees of salinity are innumerable, and their properties and uses vary accordingly. There are the salt waters of the Dead Sea—so acrid as to be nauseous to the taste; there are those of the ocean, not so acrid: there are the varieties of mineral waters, and the brine springs highly impregnated with sodium chloride. But it is not necessary to go further into this branch of the subject; all that is necessary is to understand clearly the meaning of the terms we employ, and in the following essay I shall use the words fresh, brackish, and salt, as applied to water in the sense they are popularly understood.

3. But before entering upon the discussion regarding the cause or origin of the saltness of the oceanic waters we may endeavour to ascertain whether this highly saline character has characterised these waters throughout a very long period of geological time. Now the evidence we can safely rely upon in this part of our enquiry is mainly derived from the character and affinities of the organic forms

[1] Paper read at a meeting of the Victoria Institute, January 16, 1893.

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[1] Paper read at a meeting of the Victoria Institute, January 16, 1893.

of past geological ages. At the present day the molluscan and other forms which inhabit the ocean waters are distinguishable from those which inhabit fresh water lakes and rivers, while there are numerous others, such as the *Actinozoa* or corals, star-fishes, crinoids, sea-urchins, or echinoderms, exclusively confined to oceanic waters at the present day. The Brachiopods and the Cephalopods are specially characteristic of oceanic waters of the present day, and are therefore of special value in the attempt to determine the character of the waters which they inhabited in past geological times.

4. Now representatives of all these forms are found not only in Tertiary and Secondary, but even in early Primary or Palæozoic strata. Not only in the Cretaceous and the Jurassic strata, but also in the Carboniferous, Devonian, Silurian, Ordovician and Cambrian formations do we find corals, crinoids, starfishes, sea-urchins, various forms of Brachiopods and Cephalopods, differing indeed specifically from, but sometimes generically related to, those of the present day. The forms which are thus preserved to us in a fossil state are only those which were furnished with a stony or horny skeleton or integument. Many other forms there were which had no calcareous skeleton, and consequently have not been preserved in a fossil state, but which are represented in the ocean waters of the present day; and if these be allowed for, it becomes clear that amongst the invertebrate forms of marine life, those of the present day were largely represented in very early geological periods.

5. Such being the case we are justified in coming to the conclusion that the waters of the ocean must have been salt from very early geological times; but it by no means follows that they were fully as saline as those of the present day.

The forms of life which require the high salinity of existing ocean waters were possibly represented by others capable of sustaining life when the salinity was only half as great as it is now. We know that some forms, such as those of the oyster, cockle, etc., are capable of surviving in the Baltic, or of ascending estuaries, where the water is almost brackish. Degrees of temperature, purity (or freedom from sediment), and other conditions were probably of greater importance in determining the existence of life than degrees of salinity. Adaptability to the conditions of environment has doubtless been a law of nature amongst marine forms as well as those of the air and the land throughout all past time.

6. It is scarcely necessary to state here that the occurrence of beds of rock salt in several formations, especially in the Trias of the British Isles and of Europe, affords no evidence as regards the degree of salinity of the sea water in geological times. At no period have the waters of the ocean been so saturated with saline matter as to admit of the deposition of beds of rock salt. It has sometimes been suggested that such deposits may have been formed by the accidental accumulation of sand bars, owing to which portions of the ocean have been cut off from the main mass and the salts have been deposited as the waters have decreased

and become supersaturated by evaporation. But the mode of occurrence of the known beds of rock salt lend little support to this view; and recent investigations have led to the conclusion that deposits of rock salt have been accumulated over the floors of inland salt lakes like that of the Dead Sea in Palestine, along whose banks such deposits occur in the form of terraces which once formed the bed of the inland lake itself, when at a higher level than at present, but owing to the lowering of its waters are now exposed along its western margin, as in the case of the terraced hill known as Jebel Usdûm. Another fatal objection to the view of the marine origin of salt-rock is to be found in the fact that this rock generally consists of nearly pure chloride of sodium, while ocean water contains large proportions of the chlorides of calcium, magnesium, and potassium, the precipitation of which would result in a deposit very different from that of the rock-salt of Cheshire and Worcestershire, which is composed of 98·30 per cent. of chloride of sodium and only small traces of other salts.

7. But in addition to the evidence derived from organic forms of the primæval ocean we apparently possess very remarkable direct evidence that the waters were highly saline. It is known that some strata of the Upper Silurian period in North America are saliferous, constituting the Onondaga salt group and the Trenton and Chazy limestone series.[1] These strata are characterised by large numbers of marine organisms, and there can be no doubt that they were formed in the waters of the Silurian seas. They also yield large quantities of saline waters which are used in commerce, and in which chloride of sodium predominates; and as the strata are often in the condition of basins below the level of the outer ocean, Dr. Sterry Hunt has inferred that the waters with which they are saturated were originally those of the Palæozoic ocean in which the strata were deposited. In other cases, however, where the strata are upraised above the ocean level and highly inclined, the same author considers that surface waters have gradually replaced those originally contained in the strata.[2] Thus we are justified in inferring, not only from organic, but from direct physical evidence, that the waters of the early Silurian oceans were salt.

8. On examining samples of water taken from the open ocean of various regions and far from land, it has been found that the proportion of salts and carbonates do not vary much. This is doubtless owing to that wonderful system of currents by which the waters are kept in a state of perpetual movement, and owing to which there is a constant interchange of the warmer waters of the equatorial region with the colder of the polar. Sea water is essentially a chlorinated

[1] Dana states that in the State of New York the salt is made from strong brine by sinking wells varying from 150 to 340 feet in depth. It takes from 35 to 45 gallons of this water to make a bushel of salt, whereas it takes 350 gallons of sea water for the same result.

[2] "Chemical and Geological Essays," p. 104.

alkaline mineral water, the saline contents of which consist chiefly of sodic, magnesic, potassic, and calcic chlorides and sulphates, together with a number of other substances in much smaller proportion. The total amount of dissolved contents in the water of the open ocean varies from about 28 to 39 grammes per litre. Forchhammer fixes the mean amount of such contents at 34·404 grammes per litre,[1] and the mean proportions of the constituent substances to each other and 100 parts of chlorine are as follows[2]:—

Sodium.	Magnesium.	Calcium.	Chlorine.	Total saline constituents.
14·26	6·642	2·114	100	181·10

9. What is most striking in this analysis is the large proportion of chlorine, and the greatest difficulty we are met with in order to account for the salts of sea water is the abundance of this gas. Recollecting that chloride of sodium is the most abundant salt both in most salt lakes and in sea water, we are justified in seeking for a solution to our problem by an examination into the mode of origin of salt lakes.

10. Now there is one peculiarity which characterizes all salt lakes over the surface of the globe, namely—that they have no outlet; they are closed lakes. Whether we take the case of the salt lakes of Western America, those of Central Asia and the Dead Sea, we shall find that they are not drained by rivers.

11. In such cases the lakes are constantly receiving supplies of water from streams and springs, but do not give it off in the same manner, inasmuch as it is evaporated into the air as fast as it falls. In the case of freshwater lakes it is otherwise. Here the water of the streams which enter the lake is at least partially discharged by means of rivers flowing out, in consequence of which the water remains fresh, as the saline ingredients are carried away as fast as they are delivered. Of these two varieties of inland lakes we have remarkable examples in the case of the Dead Sea and the Sea of Galilee. In the former case the river Jordan entering at the northern end keeps up a constant supply, but this lake, which is about 1292 feet below the level of the Mediterranean, has no outlet, in consequence of which the water supplied by the Jordan passes away into the atmosphere in the state of vapour. In the case of the Sea of Galilee it is otherwise. The river which enters at the north passes out again at the south; hence the water of the lake is fresh and supports an abundant fauna of fishes and molluscs, while the waters of the Dead Sea are (as the name indicates) absolutely destitute of living beings, and fish entering it from the Jordan immediately perish. If there had been an outlet to the southwards from the Dead Sea into the Gulf of Akabah, and a continuous stream had been flowing from the time the depression was formed, the waters of the Dead Sea would have only differed from those of the Sea of Galilee by a somewhat greater proportion of salts and carbonates. Several other examples might be cited, but those of the Sea of Galilee and the Dead Sea are the most familiar and striking.

[1] Phil. Trans. civ. 303, *et seq.* [2] Watt's Dict. Chem., vol. v. 1019.

12. There are two ways by which we may account for the salinity of the ocean waters from very early periods of geological time. First, by supposing that the primæval waters were saturated with acid gases which were held in suspension in the vapour surrounding the incandescent globe; or secondly, that the salinity resulted from a process resembling that by which salt lakes of the present day have been formed.[1]

13. We must, I think, concur with Dr. Hunt that from some cause or other, chlorine largely abounded in the waters of the primæval ocean, as by far the greater proportion of the salts are chlorides, and chlorine is but very slightly represented in river waters at the present day.

14. In contrast to the above, which may be called "the chemical theory," we may now consider that which may be called "the geological theory," though it very much depends upon certain chemical processes.

15. If we compare the analyses of waters brought down by rivers into the ocean at various parts of the globe we shall find that the matters in solution are very much the same as those which we find dissolved in oceanic waters; the proportions are doubtless immensely different, but the ingredients are essentially similar. Now, what are the dissolved ingredients of river waters? They are calcium, magnesium, sodium, potassium, a little iron, silica, alumina, and other matters, in combination with carbon-dioxide (carbonic acid gas), sulphuric acid, hydrochloric acid. Of these the carbonates of lime and magnesia are the most abundant, but chlorides of sodium and magnesium are almost always present even in waters where there can be no suspicion that they have been introduced by any artificial means. These constituents are also found in even larger proportions in the waters of natural springs; and in

[1] Of the former method Dr. Sterry Hunt may be considered the chief exponent, and in order that I may not unintentionally misrepresent his views I will give them here in nearly his own words. Referring to that period in the physical history of our globe in which it may be presumed to have been in a molten state surrounded by an atmosphere and an envelope of vapour of water, he says:—"There would be the conversion of all the carbonates, chlorides and sulphates into silicates, and the separation of the carbon, chlorine and sulphur in the form of acid gases which, with nitrogen, vapour of water, and a probable excess of oxygen could form the dense primæval atmosphere. The resulting fused mass would contain all the bases as silicates, and must have resembled (when consolidated?) certain furnace slags or volcanic glasses. The atmosphere charged with acid gases which surrounded this primitive rock must have been of great density. Under the pressure of a high barometric column condensation could take place at a temperature much above the present boiling point of water, and the depressed portions of the half-cooled crust would be flooded with a highly heated solution of hydrochloric and sulphuric acids, whose action in decomposing the silicates can easily be understood. The formation of the chlorides and sulphates of the various bases and the separation of silica would go on until the affinities of the acids were satisfied, and there would be a separation of silica taking the form of quartz, and the production of sea-water holding in solution, besides the chlorides and the sulphates of sodium, calcium, and magnesium, salts of aluminium and other metallic bases. The atmosphere being thus deprived of its volatile chlorine and sulphur compounds, would gradually approximate to that of our own time, but would differ in the greater amount of carbonic acid gas." "Chemical and Geological Essays," p. 40 (1875).

such chlorine occurs, sometimes in considerable quantity, in combination with sodium, magnesium, and potassium. Spring water coming as it does directly from the strata, or from rocks of various kinds, is generally free from any external or artificial ingredients, hence it may be regarded as the chief source of supply of the carbonates and salts found in streams and rivers. If we enquire what is the origin of spring water, the reply is simple. It is water which originally falling on the surface as rain or snow has percolated downwards into the rocky crust, and taking up the soluble matters with which it comes in contact, bursts forth at the surface along lines of fault, fissure, or other natural ducts. The relative proportions of the ingredients of sea water and of rivers or lakes may be gathered from the selected examples on p. 171.

16. From the above results of the analysis of various waters, it will be seen that there is no essential difference between the waters of the ocean and those of lakes and rivers except in the proportions of the dissolved ingredients. There are, of course, occasionally substances specially abundant, as is the case with bromine in the waters of the Dead Sea, probably derived from the volcanic district on its borders; on the other hand, silica ($Si\ O^2$), which is not mentioned in the waters of the Atlantic Ocean in the analysis of Von Bibra, is certainly present in those waters, and supplies the material from which sponges, diatoms, and radiolaria build up their skeletons. It will be observed also that chlorine and sulphuric acid is present in all the waters, and these gases uniting with the alkalies, give rise to the salts which are so abundant in the waters of the ocean and of closed lakes.

17. In considering the manner in which springs and surface waters have become impregnated with salts and carbonates, we have to recollect that all rocks decompose in presence of the atmosphere. This is mainly due to the carbonic acid (carbon-dioxide) contained in the air and rain water, which acts upon felspathic rocks, composed, as we have seen, of double silicates of alumina, potash, and soda. Ebelman has well explained the process by which basaltic and similar rocks are decomposed under the influence of the atmosphere. The carbonic acid (carbon-dioxide) combines with the lime and magnesia, while the silica is liberated in a soluble form. The felspar is more stable than the pyroxene and hornblende, but it ultimately gives way, forming a hydrous silicate of alumina. Thus we can account for the presence of carbonates of lime and magnesia, free silica, and by a further process in presence of sulphuric acid and chlorine of the various sulphates and chlorides.

18. Now, as bearing on the fact of sodium chloride (or common salt) being the chief ingredient in oceanic waters, as well as in those of the Dead Sea and most salt lakes, we must recollect that the soda-felspars are much more soluble than the potash-felspars, and on this account we have probably a true cause of the predominance of sodium chloride. The rocks composed in the main of such felspars as labradorite, albite, oligoclase, and andesine, were therefore more powerfully acted upon than those composed of orthoclase

PROPORTION OF SOLUBLE INGREDIENTS IN THE WATERS OF THE OCEAN AND SPECIAL LAKES AND RIVERS.
Parts in 1,000,000.

	Total Solid Contents.	Ca.	Mg.	Na.	K.	CO_2.	SO_4.	Cl.	Br.	SiO_2.	Fe.	Authority.
Atlantic Ocean (41° 18′ N., 36° 28′ W	38,400	556	1,198	11,719	668	...	3,029	20,839	387	...	...	Von Bibra.
Caspian Sea (2 versts S.W. of Pischnoi) ...	6,296	191	409	1,444	139	77	1,337	2,737	...	...	40	Göbel.
Dead Sea...	240,483	9,000	19,883	47,918	6,385	...	497	154,442	2,176	...	11	Herapath.
Rhine at Basle	169	55	4·8	0·6	...	86	15·4	1·5	...	2·1	...	Pagenstechor.
Aar, near Berne	216	66	10·0	0·3	...	103·3	33·7	0·3	...	2·7	...	,,
Severn, Wales...	38.7	3·0	2·0	6·1	1·2	2·0	12·8	8·2	...	2·0	...	Franklin and Odling.
Thames at Twickenham...	321	83·8	4·7	9·2	4·2	119·9	31·4	14·2	...	3·9	...	Clark.
Thirlmere	51·5	4·3	1·2	4·9	...	10·9	7·5	11·0	...	0·7	...	Way.
Bala Lake	27·9	1·5	0·8	3·9	0·9	1·9	3·5	7·3	...	0·3	...	Frankland.

Decimals are omitted in the case of sea waters.

and sanidine; but even in these cases many orthoclase granites contain proportionate quantities of the soda felspars such as oligoclase and albite, and the decomposition of these components would hasten that of the less soluble varieties.

19. It seems not improbable from certain considerations connected with the organic structures of the ancient world, that carbon-dioxide was more abundant in the atmosphere of Palæozoic times than at present. The enormous quantity of carbon which must have been extracted from the air during the Carboniferous period in order to the formation of the beds of coal at intervals all over the world, seems to favour this view; and if this be so, then we may suppose that previous to the Carboniferous period, the air was highly charged with carbon-dioxide, and the process of decomposition on the land surface was carried on with even greater rapidity than at the present day; but even had this not been the case, it only requires a sufficiently long period in order to bring about the chemical reactions necessary to the salinification of the oceanic waters.

20. We are now approaching the conclusion of our enquiry. From the examples of closed lakes we can determine the process of salinification with the utmost certainty. Throughout greater or shorter periods, these lakes have been receiving the waters of rivers bringing down, both mechanically suspended sediments and chemically dissolved salts, silicates, and carbonates. The sediments are precipitated over the bottom of the lakes, and the water being carried off into the atmosphere in the form of vapour as fast as it enters, leaves behind the dissolved ingredients. These necessarily augment in quantity, and ultimately the waters of the lakes become saturated with salts and carbonates, which are then deposited.

21. Now the ocean is a closed lake of enormous magnitude. Throughout all geological time it has been receiving continual supplies from rivers, bringing down not only sediment, but salts and carbonates, together with free silica, in solution. The sediment is deposited over the ocean floor, and generally not far from the lands, while the dissolved ingredients are carried by the currents into all parts. Meanwhile the ocean surface is constantly giving off, particularly over the equatorial regions, enormous quantities of vapour, which are carried into the higher regions of the atmosphere, and are precipitated in the form of rain and snow over the lands. Part of course falls on the sea again, but the greater quantity falls on the land surfaces, and is returned to the ocean in streams charged with a fresh supply of the salts and carbonates it had left behind in the ocean.[1] The consequence of this process must clearly be that the saline ingredients have been increasing in the oceanic waters from the earliest periods down to the present day. As regards the carbonates of lime and magnesia, and the silica which are being carried into the ocean by the rivers, we have no difficulty in accounting for their uses. Of these materials, the shells and skeletons of the molluscs, echinoderms, reef-building

[1] This process of evaporation and supply by rivers is accurately described in the Book of Ecclesiastes i, 7.

corals, foraminifera, sponges, radiolarians, and diatoms and other forms are built up, and as these structures are continually being formed, and the materials solidified as fast as they enter the oceans, there is no reason why they should augment. Hence the proportion of carbonates of lime and magnesia in the ocean waters may be very much the same now as it was in Silurian and Carboniferous times.

22. We are thus brought to the conclusion that the saltness of the sea may have originated in very much the same way as has that of the Dead Sea, Lake Oroomiah, or the Great Salt Lake of Utah, or many others which might be named, and which possess in common the characteristic of having no outlet. When the great envelope of vapour which surrounded the incandescent globe began to condense upon its cooling surface, the resulting waters, though containing, as Dr. Sterry Hunt supposes, acid gases, were destitute of saline ingredients. The process of salinification began with the first streams which entered the seas from the bordering uplands, and this process carried on throughout the long ages preceding the Silurian period brought the waters to a condition suited to sustain the life of forms of inhabitants representative of those which inhabit the ocean at the present day. These long ages may be supposed to include, not only the Archæan and Azoic periods, but that during which the first crust was in course of formation over the incandescent globe.

II.—On some new Reptiles from the Elgin Sandstone. By E. T. Newton, F.G.S. From the Proceedings of the Royal Society, Vol. 52.

DURING the last few years a number of Reptilian remains have been obtained from the Elgin Sandstone at Cuttie's Hillock, near Elgin, which are now in the possession of the Elgin Museum and of the Geological Survey. These specimens represent at least eight distinct skeletons, seven of which undoubtedly belong to the Dicynodontia, and one is a singular horned Reptile new to science. All the remains yet found in this quarry are in the condition of hollow moulds, the bones themselves having entirely disappeared. In order, therefore, to render the specimens available for study, it was necessary, in the first place, so to display and preserve these cavities that casts might be taken which would reproduce the form of the original bones. Gutta-percha was found to be the most suitable material for taking these impressions; and in some instances, especially in the case of skulls, the casts had to be made in several parts and afterwards joined together.

The first specimen described is named *Gordonia Traquairi*; it is the one noticed by Dr. Traquair in 1885, and referred to the Dicynodontia; besides the skull, it includes fragmentary portions of other parts of the skeleton, and is contained in a block of sandstone which has been split open so as to divide the skull almost vertically and longitudinally. The two halves have been so developed that casts made from them exhibit the left side and upper surface, as well as the main parts of the palate and lower jaw. In general

appearance this skull resembles those of *Dicynodon* and *Oudenodon*. The nasal openings are double and directed laterally; the orbits are large and look somewhat forwards and upwards. The supra-temporal fossa is large, and bounded above by the prominent parieto-squamosal crest, and below by the wide supra-temporal bar, which extends downwards posteriorly to form the long pedicle for the articulation of the lower jaw. There is no lower temporal bar. The maxilla is directed downwards and forwards to end in a small tusk. Seen from above, the skull is narrow in the inter-orbital and nasal regions, but wide posteriorly across the temporal bars, although the brain-case itself is very narrow. There is a large pineal fossa in the middle of a spindle-shaped area, which area is formed by a pair of parietals posteriorly and a single intercalary bone anteriorly.

The palate is continuous with the base of the skull; the pterygoids on each side send off a distinct process to the quadrate region. Towards the front the median part of the united pterygoids arches upwards, and the outer sides descend, forming a deep groove; from the evidence of other specimens it is clear that the palatines, extending inwards, converted this groove into a tube, and thus formed the posterior nares. The ramus of the lower jaw is deep, with a large lateral vacuity, and the two rami are completely united at the symphysis. The back of this skull is not seen, but two other specimens, referable to this same genus, show that the occiput had two post-temporal fossæ on each side.

This specimen is distinguished from *Dicynodon* by the presence of two post-temporal fossæ on each side of the occiput, by the small size of the maxillary tusk; and probably by the elongated spindle-shaped area enclosing the pineal fossa, and also by the slight ossification of the vertebral centra.

A second and much smaller specimen, provisionally referred to *G. Traquairi*, has, besides the skull, a fore-limb well preserved. The humerus of this shows the usual Anomodont expansion of its extremities; its large deltoid crest is angular, and set obliquely to the distal end.

Three other species are referred to the same genus, namely:—

Gordonia Huxleyana, which is distinguished from *G. Traquairi* by its proportionately wider and more depressed skull, and by the absence of the concavity between the orbits which is present in the latter species. The humerus has the distal extremity oblique to the deltoid crest, which was probably rounded and not angular.

G. Duffiana has the skull even wider than in *G. Huxleyana*, and the portion of a humerus found with this skeleton has the two extremities set nearly at right angles to each other.

G. Juddiana has an elongated skull resembling that of *G. Traquairi*, but the parietal crests are less developed, the bones of the nasal region are much thickened and overlap the nasal apertures, the small tusk is placed a little further back and points more directly downwards, and the pineal fossa is smaller than in either of the other species.

A second generic form is named *Geikia Elginensis*. This is a skull nearly allied to *Ptychognathus*, Owen, but is distinguished by its shorter muzzle and the entire absence of teeth; the upper part of the skull, between the orbits, is also peculiar, forming a deep valley open anteriorly, with a ridge on each side, the anterior end of which forms a large prominence above and in front of the orbit. The occiput has only one (the lower) post-temporal fossa open on each side. The maxilla is produced into a tooth-like prominence, which occupies a similar position to the tusks of *Gordonia*; but the bone is too thin to have supported a tooth, and in all probability it was covered by a horny beak. The lower jaw has a strong symphysis, a distinct lateral vacuity, and the oral margin, at the front of each ramus, bears a rugose prominence.

Elginia mirabilis is the name proposed for the skull of a Reptile, which, on account of the extreme development of horns and spines, reminds one of the living Lizards *Moloch* and *Phrynosoma*. The exterior of this skull is covered in by bony plates, the only apertures being the pair of nostrils, the orbits, and the pineal fossa. The surfaces of the bones are deeply pitted, as in Crocodiles and Labyrinthodonts. The horns and spines, which vary from $\frac{1}{4}$ in. to nearly 3 in. in length, are found upon nearly every bone of the exterior. The development of the epiotics and the arrangement of the external bones resemble more the Labyrinthodont than the Reptilian type of structure, while the palate, on the other hand, conforms more nearly to the Lacertilian type, and, with the exception that the pterygoids are united in front of the pterygoid vacuity, agrees with the palate of *Iguana* and *Sphenodon*. There are four longitudinal ridges along the palate, some of which seem to have carried teeth. The oral margin was armed with a pleurodont dentition, there being on each side about twelve teeth with spatulate crowns, laterally compressed and serrated. With the exception of the smaller number of the teeth, we have here, on a large scale, a repetition of the dentition of *Iguana*. This peculiar skull seems to show affinities with both Labyrinthodonts and Lacertilians, and is unlike any living or fossil form; its nearest, though distant, ally apparently being the *Pareiasaurus* from the Karoo Beds of South Africa.

REVIEWS.

I.—Fauna der Gaskohle und der Kalksteine der Perm-formation Böhmens. Band III. Heft 2. By Prof. Anton Fritsch, of the Bohemian University of Prague. Prague, 1893.

ALL who are interested in the study of the Palæozoic Vertebrata will welcome the appearance of a new part of Prof. Anton Fritsch's great work on the Permian Fauna of Bohemia, dealing, as this part mainly does, with a problematic group of extinct fishes, whose affinities have troubled palæichthyologists since the time of Agassiz. It is that of the Acanthodei, the consideration and illustration of which occupy twenty-six of the thirty-two pages, and seven

of the twelve plates contained in the present "Heft," while in the remainder a commencement is made with the description of these "Teleostomi," which we have been accustomed to call "Ganoidei."

Only one family of Acanthodei is represented in the newer palæozoic rocks, that of the Acanthodidae, having only one dorsal spine, and of this family the genera and species occurring in the Permian of Bohemia are first treated descriptively, a separate chapter being reserved for general considerations. Three genera come under consideration, namely *Traquairia*, *Protacanthodes* and *Acanthodes*, of which the two former are new.

Traquairia pygmaea is the name given by Dr. Fritsch to a small Acanthodian fish whose salient peculiarities are—the total absence of ventral fins and the tooth-like acumination of the posterior angles of the scales,—the dorsal spine is, as in Acanthodes, behind the anal. Numerous examples of the one species of the genus have occurred at Nyřan, and a few also at Třemošna.

In *Protacanthodes* the scales have also a spine or tooth-like projection which, however, passes off from their hinder *margin*; the ventrals are described as very small, while behind them a long narrow *median* dermal fold passes to nearly as far as the anal spine, which as in *Traquairia* and *Acanthodes* is placed in front of the dorsal. It is much to be regretted that only one single example of the one species, *P. pinnatus*, Fr., has occurred. Dr. Fritsch seems himself a little doubtful about the minute ventrals, and I cannot altogether rid myself of the notion, that what he interprets as a median fold may possibly be *one of a pair* of ventral fins, fringe-like as they are in *Acanthodes* proper. Of the last mentioned genus three species are noticed, of which *A. punctatus* is founded upon spines occurring at Kounova, while *A. Bronni*, Ag., and *A. gracilis* (Beyrich) are retained as distinct species.

As regards the general structure and morphology of the group, Prof. Fritsch exercises a wise caution in not committing himself to such wonderfully detailed results as those announced by Reis in a paper published three years ago.[1] He places the Acanthodei among the Elasmobranchii as is now done by most authors, and among the evidences of this affinity he adduces the tooth-like projection on the posterior aspect of the scale, in *Traquairia* and *Protacanthodes*, which he compares with those of *Centrina*. The resemblance in shape is interesting, but I cannot follow the author when he says: "Es zeigt sich dass die älteren Formen der Acanthodiden diese bezahnten Schuppen trugen und ihre jüngeren Vetreter Acanthodes diesen Zahn verloren und blos den viereckigen Theil ohne jeden Vorsprung behalten haben." I certainly cannot regard either *Traquairia* or *Protacanthodes* as specially archaic in structure, and I certainly know of no Devonian or Carboniferous Acanthodian which is possessed of similar "bezahnte Schuppen."

As regards the skeleton he finds that the cartilage calcifications are as in the Xenacanthidæ formed by polygonal plates. No teeth

[1] Geognostische Jahreshefte der königl. baier. Oberbergamtes 1890.

were discovered in any of the Bohemian genera,—the edentulous character of *Acanthodes* being thus conclusively confirmed.

In the shoulder-girdle he designates the well-known ossicle supporting the pectoral spine as "clavicula" and therefore does not adopt Mr. Smith Woodward's view that this element in *Acanthodes* is a basal piece or Basipterygium, while interpreting as clavicle the very same piece as it occurs in *Diplacanthus*. Here, however, Prof. Fritsch expresses himself very cautiously, saying that comparative anatomists would find a difficulty in agreeing about these points even "wenn sie die Sachen frisch vos sich hatten."

The morphology of the paired limbs of *Acanthodes* is certainly a very difficult question, and Dr. Fritsch ventures to suggest a new theory, namely that the entire pectoral spine is in fact a calcified archypterygium. To that view I cannot say I am converted, any more than to the very different one entertained by Mr. Smith Woodward.

Before leaving the Acanthodei, Prof. Fritsch inserts a couple of pages concerning *Machæracanthus Bohemicus* (Barrande), which he, along with Reis, considers referable to this group, owing to the fact that in one of the specimens described and figured by Barrande, a bone resembling an Acanthodian clavicle occurs in close association with fragments of two of those spines, while on the under side of the stone, square shaped scales like those of *Acanthodes* are found. For this he proposes the new generic and specific names *Dinacanthodes Süssii*. Now it is evident that if the specimen with the clavicular fragment discovered by Prof. Süss belongs to the same species as the others also described and figured by Barrande on a preceding page of his work as *Ctenacanthus Bohemicus*, and Prof. Fritsch nowhere says that it does not, the latter specific name has undoubted priority and cannot be displaced.

We must agree with the author in desiring a fresh investigation into the nature of the other species of *Machæracanthus*, on the results of which indeed depends the validity of the name *Dinacanthodes*. For if the Bohemian spine should really prove to belong to the same genus with Newberry's *Machæracanthus sulcatus*, the type of the genus, then Prof. Fritsch's new name cannot be maintained.

After a brief notice of a scale of *Megalichthys* (*M. nitens*, Fr.) from Kounová, the author enters the domain of the Acipenseroid fishes, for which he, however, retains the older, though less appropriate name of Chondrostei, the description of the remarkable genus and species *Trissolepis Kounoviensis* bringing the present part to a conclusion. This he makes into the type of a new family, Trissolepidae, of which I shall translate his definition.

"Body Palæoniscus-like, scales behind the head denticulated, on the body cycloid, on the tail rhombic. Anterior margins of fins without fulcra. Palate with strong teeth. Gill arches with strong gill-rakers. Middle line of the back only in front of the dorsal fin with V scales, which gradually pass into the fin rays."

Now as these characters appear to me to be only of generic and

not of family importance, I cannot see in them any sufficient reason for separating *Trissolepis* from the Palæoniscidae, as they now stand, and when that enormous family comes to be subdivided, I should be inclined to place the genus in question not far from *Amblypterus* on account of the direction of the suspensorium and the form of the opercular apparatus.

Anyway, *Trissolepis Kounoviensis* is a most interesting fish, the consideration of which leads us to imagine—what would the older writers who pinned their palæichthyological faith to Agassiz's system, have said to a "Lepidoid" with round scales on its body and angular ones on its tail! But this is now not the only instance of such an apparent anomaly.

The restored drawing of *Trissolepis* is indeed very nice, but it seems to me that he has put the orbit in an impossible position for a fish of its affinities. If Dr. Fritsch should prove correct in this detail, then it will have to be frankly conceded that the Trissolepidæ do form a family quite sufficiently separated from the Palæoniscidæ.

A curious feature of the genus is the presence of large, prominent, tooth-like gill-rakers attached to the branchial arches on their anterior aspect. *Apropos* of this, Prof. Fritsch observes in a footnote that, "die starke Bezahnung der Kiemenbögen lässt die Frage enstehen ob *Harpacanthus fimbriatus*, Traquair, nicht ein ähnlich bezahnter Kiemenbogen ist." Now I can only answer that all Teleostomous ossified branchial arches, which I have ever examined, had a groove posteriorly for the branchial vessels and nerves, which is *not* found in *Harpacanthus*; secondly, that I never saw in any of them a central pulp cavity or canal, which *is* present in the spine to which I gave the above-mentioned generic name. The question need not, I think, arise again.

Such criticisms, notwithstanding Prof. Fritsch's new part is a very valuable contribution to palæichthyological science, and one on the production of which its author is certainly to be congratulated.

R. H. Traquair.

II.—A. E. Brehm, Merveilles de la Nature: La Terre, les mers et les continents, Géographie Physique, Géologie et Minéralogie; par Ferdinand Priem. Paris, 1893. Royal 8vo. pp. 708, with 757 Illustrations. (J. B. Baillière et Fils.)

So many important works on Physical Geography have appeared during the last twenty-five years that one is led to marvel whence the source of supply of this perennial stream of literature can have been derived.

We owe the initiation of this form of knowledge to the greatest naturalist and traveller of his time, Alexander von Humboldt, best known to English students by his latest work, "Kosmos" (1848), in which he contemplates all created things as linked together and forming a perfect whole, animated by internal forces. Charles Darwin's Journal of a Naturalist, in a voyage round the world, is another work which doubtless contributed to lay the foundations of

the many subsequent Physiographical studies which have since seen the light in this country.

The most important French work, *bearing the same title*, "*La Terre*," as the present work, was written and published by J. Elisée Reclus, the well-known French geographical writer and traveller, in Paris, about 1864, and an English edition in four volumes appeared in 1871, which was followed by a second edition some years later. Professor Edouard Suess in Vienna has also contributed "Das Antlitz der Erde" (the face of the Earth) and his lamented son-in-law, Prof. M. Neumayr, has published "Erdgeschichte der Erde" (the History of the Earth); while in England, the writings of Lyell, Ansted, Page, Lapworth, Huxley, Geikie, Young, Douglas, and many others have reduced the study of the Earth to a definite science, but at the same time have surrounded it by a charm peculiarly its own.

The Editor of this new Edition of Brehm's celebrated work we are told has carefully brought his subject up to date in all matters relating to most recent scientific researches. In the first part we have an outline of the history of geology, then we consider the terrestrial globe in its relation to the other heavenly bodies, and afterwards study the various elements of our planet: its atmosphere, its lands and seas.

A great part of the work is occupied with a description of those continual changes of the terrestrial surface, due to the action of the seas, to running waters, and to the subterranean forces; especially the questions relative to glaciers, volcanoes, and earthquakes, are fully treated with all the development which they admit.

The minerals and rocks are next passed in review, and special attention is directed to economic materials: the metals, and the precious stones. The volume terminates with an outline of the faunas and floras which people the earth. The book is profusely illustrated with 757 engravings, many of them of most excellent merit; but in some instances it is difficult to understand the reason for their introduction. Thus in the sections relating to the faunas of the globe, one would have expected to see the most characteristic forms figured, rather than those which are more rare. The "Lemming" is not more characteristic of circumpolar lands than the white bear, the walrus, the musk sheep, the reindeer, or the elk.

The "tree-porcupine," is not so characteristic of North America as the Bison, now, alas, nearly exterminated by man, or the Prairie-Dog (*Spermophilus*). The *Orycteropus* of the Cape rather represents its distant South American relatives, the Great Ant-eater, the Tree-sloth, and the Armadillos; and with the Pangolin (*Manis*) points to a former migration of the South American Edentata into South Africa, possibly *viâ* the old Antarctic Continent. But the Zebras, Quaggas, Elands, and other Antelopes; the Giraffes, Hippopotami, and Elephants, with Lions, Hyænas, and Ostriches, better represent the Cape-fauna than the Aard-Vark or the Manticora Beetle. The "Aye-aye" (*Cheiromys*) is not so characteristic of Madagascar as the ordinary Lemurs, being an extremely rare form in that Island.

The "Bower-bird" (*Chlamydera maculata*) is the only illustration of the fauna of Australia; the *Thylacinus* and *Ornithorhynchus* for Tasmania; and the *Apteryx* for New Zealand.

Under "the Calcareous rocks and their principal varieties" we have an account and illustrations of "Travertin," with plant-impressions; of washings of the Chalk, showing the various forms of *Foraminifera*, of which it is so largely built up; of Crinoidal limestone and figures of the various forms of *Encrinus* and *Pentacrinus*, of whose broken remains they are composed. Of Corals and Coral-reefs with figures of the zoophytes and their skeletons and of the Islands and Barrier-reefs built up by their combined labours. Of the various kinds of Radiolarians and Foraminifera, both recent and fossil, and the rock-formations their microscopic organisms have so largely assisted to form: all this is excellently told. There are numerous figures of fossil organisms, ranging from the *Paradoxides* of the Cambrian to the Bernissart *Iguanondon* and from the *Archæopteryx* of Solenhofen to the Mammoth of Siberia and the *Cervus giganteus* of the Irish peat-deposits. On p. 10, Fig. 23, of *Lepidodenron aculeatum*, the block has accidentally got turned upside-down, the leaf scars being reversed. The woodcuts of geological scenery are most excellent. The Book (like so many others printed in France and Germany) is issued *without binding* in a paper wrapper, the effect of which is that the edges become speedily "dogs-eared." It is to be regretted that so fine a work should not be issued in an equally handsome cover, and well bound. We wish the new edition of Brehm all the success which has attended his other and earlier publications.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—Annual General Meeting.—February 17th, 1893.—W. H. Hudleston, Esq., M.A., F.R.S., President, in the Chair.

The Secretaries read the reports of the Council and of the Library and Museum Committee for the year 1892. In the former the Council once more congratulated the Fellows on the continued financial prosperity of the Society.

The number of Fellows elected during the year was 40; of these 33 qualified before the end of 1892, together with 18 previously elected Fellows, there being thus a total accession of 51 Fellows during the twelvemonth. As, however, from this number a deduction of 59 must be made for losses by death, resignation, and removal, and for new Fellows compounding, there is an actual decrease in the number of Contributing Fellows of 8. The total number of Fellows, Foreign Members, and Foreign Correspondents at the close of 1892 was 1400.

The Balance-sheet for the year 1892 showed receipts to the amount of £2927 14*s.* 9*d.* and an expenditure of £2358 11*s.* 3*d.* Moreover, the sum of £528 3*s.* 0*d.* was expended in the Purchase of Stock,

and the balance in favour of the Society at December 31st, 1892, amounted to £327 19*s.* 10*d.*

The Report of the Council further referred to the successful claim and recovery from the Commissioners of H. M. Inland Revenue of four years' taxes under Schedules A and C, and in conclusion announced the awards of the various Medals and proceeds of Donation Funds in the gift of the Society.

The Report of the Library and Museum Committee enumerated the additions made during the past year to the Society's Library, announced the completion of 22 previously imperfect sets of serials, and the continuation of the work of registering the type-specimens in the Museum by Mr. C. Davies Sherborn.

In presenting the Wollaston Medal to Professor Nevil Story Maskelyne, M.A., F.R.S., F.G.S., the PRESIDENT addressed him in the following words:—Professor Maskelyne,—

The Council of the Geological Society have this year awarded to you the Wollaston Medal, in recognition of your researches in those branches of science which the Founder himself cultivated with so much success. We do not forget that Wollaston invented the reflecting goniometer, and that no one has been more skilful in the use of that instrument than yourself. Thirty years ago you were enabled, in this way, to make an exact determination of the form of the minute crystals of Connellite; and the later discovery of larger crystals of that mineral has only served to confirm the accuracy of your original determination. During the thirty-five years that you have occupied the Chair of Mineralogy at Oxford you have ever insisted on symmetry as being the essential feature of the crystalline systems. Contemporaneously with your professional duties you devoted twenty-three years of your life to the development of the mineral collections at the British Museum. These collections had for some years previously been without a mineralogist in charge. With the co-operation of the late Mr. Thomas Davies, your apt pupil and assistant, the collection was rearranged; and when you left the Museum to enter Parliament, in 1880, the classification of the entire collection had reached a high pitch of perfection, while the collection itself had been in many respects enriched.

The investigation of extra-telluric bodies has long since attracted your attention, though the want of a chemical laboratory must have been felt by one who had already proved, from his numerous chemical papers, the interest he took in that science. Failing this, you sought to recognize the individual minerals by the aid of the microscope, working on thin sections—a method now universally adopted in the study of terrestrial rocks. In this way, thirty years ago, you were enabled to determine many of the most important ingredients of meteorites, by means of the relation of the axes of optic elasticity to known crystallographic lines. The microscope was further applied to the mechanical separation of the different mineral ingredients of a meteorite, and the existence of such minerals as enstatite and bronzite demonstrated. Your research on the mineral constituents of the Busti meteorite will long remain an example to future workers. Further, in conjunction with the late Dr. Flight, you described the minerals of the diamantiferous rock of South Africa, suggesting that an enstatite rock, at points of contact with carbonaceous shales, was probably the original home of the diamond—an explanation which is now generally accepted.

Although for several years past your energies have found employment in another direction, we may venture to hope that your interest in those branches of science which Wollaston was desirous of promoting is in no wise lessened; and we trust that

you may yet achieve results such as shall even further justify the Council in the selection they have made.

Professor MASKELYNE, in reply, said:—Mr. President,—

In receiving at your hands the Wollaston Medal, I beg to thank the Council for the great honour they confer on me, and you, Sir, for the generous review in which you have sketched my past scientific life. When my first surprise at the Award gave way to other thoughts, the first of them was one of gratification at the Council having this year determined to give the Medal for studies so nearly connected with Wollaston's work, and to furthering which he rendered such distinguished services. To these you have alluded; and, in the kindly view you have taken of my work, I thank you for associating with it the names of some of those to whom I was much indebted in its achievement.

You have alluded, Sir, to the period—nearly a quarter of a century—that I was working at the British Museum as head of the Mineral Department. I am proud of the work done in those years, and it was done, as most good work is done, by few hands—mostly by those of Mr. Thomas Davies and myself. Davies came to me a young man fresh from the sea, and absolutely innocent of any scientific knowledge. He died a few weeks ago, in many ways an accomplished man—the best judge of a mineral in this country, and an admirable petrologist—a worthy son of William Davies, and a worthy recipient of the Wollaston Fund, which was awarded him some years ago. And, Sir, I have to thank you for naming another of the helpers in my work—Dr. Walter Flight. He, too, is no more; and there died in him one of the finest of laboratory manipulators and a very accomplished chemist.

But one name I must supply, of a man who more than thirty years ago came to London for a visit and remained to work in the Museum for some time. I allude to Viktor von Lang, the partner of Joseph Grailich in the splendid work done by the Vienna school of crystallography and physics, and who had already then a European name. That period of my life, in the continual companionship of so finely trained a physicist and crystallographer, was like a second education.

Then, Sir, you have alluded to the little school, if I may call it so, of Crystallography connected with my Chair at Oxford, and to the results of my teaching. The deduction of the laws of morphological and physical symmetry in crystals from the fundamental law of rational indices lay as a germ, though entirely undeveloped, in the Treatise and tracts of my late friend and master in the study of the science, Professor Miller of Cambridge. Modern crystallography has grown from that germ, and if I have helped in promulgating it in England through my lectures, I owe more to the students who attended those lectures than they owe to me in guiding them; for they have always kept high the standard of crystallographic work in their investigations as in their teaching. Among these I must mention my old friend, W. J. Lewis, now Professor at Cambridge; and I need only allude to the remarkable memoirs on "Thermic Dilatation in Crystals" and on the "Optical Indicatrix" by the able mathematician who succeeded me at the British Museum, Mr. Fletcher, and to the fine work of his first assistant, Mr. Miers, to justify me in saying that if I have had any merit in directing such men upon their way, it is to their own qualities that the success of that little Oxford school is due. Happily, if it were possible, would I divide that Medal among those who have so contributed to the winning of it, and retain as my own share the grateful remembrance that you, Sir, and the Council have thought me worthy to receive it, with the features stamped on it of that distinguished Englishman its Founder, the man to whom we owe the instrument—so simple, so accurate, and so indispensable—the reflection-goniometer; the instrument which made it possible for crystallography to become an exact science.

Finally, in respect to the last part of your observations, I may say that of the many duties imposed on me by my country during the past few years, I am relieved now of one of the weightiest, and shall be able, I trust, to devote much of the leisure of what may be left to me of life to the subjects which were heretofore my chief interest; and in cordially thanking you, Mr. President, and the Council for this, the greatest honour you can confer, I may assure you that it will be a great incentive to me still to strive to be worthy of it.

The PRESIDENT then handed the Murchison Medal to the Rev. Osmond Fisher, M.A., F.G.S., and addressed him as follows:—Mr. Fisher,—

The Council have this year awarded to you the Murchison Medal, together with a sum of Twenty Guineas, in consideration of the work you have done in the general advancement of geological science. They recognize the importance of your work at once as a stratigraphical geologist and as a physicist who has devoted his attention to problems in connection with the Earth's crust. It is now nearly forty years since your paper on the Purbeck strata of Dorsetshire made its appearance, worked out while you had charge of a parish in Dorchester, your connection with this part of the world arising from the fact that your father was formerly Vicar of Osmington. During the last 30 or 35 years a very great number of works have eminated from your pen, and have been published either separately or in the Proceedings of our own or of some other Society.

These works attest the wide range of the subjects in which you have taken an interest and the extent of your scientific research. The subjects may be classified under four principal heads:—1. Earth sculpture and its results; 2. The discrimination of the various superficial deposits collectively spoken of as Drifts; 3. Description of the stratigraphy and palæontology of the later Jurassics of Dorsetshire and the Older Tertiaries of the Isle of Wight; 4. Investigations into the conditions of the Earth's crust and speculations as to the causes of the great operations which take place therein, either observed in action or inferred from their results.

Whether dealing with denudation in Norfolk, with the Bracklesham Beds on the coasts of the Channel, or making use of mathematical analysis to determine what must be the resultant form and status of the Earth on the hypothesis of a certain not improbable combination of forces, brought to bear upon certain possible conditions of the crust, you have given evidence of that philosophic spirit which has ever been your characteristic. And we have also seen how suggestive your work has been from the large series of similar investigations which have often followed the publication of your results.

The Rev. O. Fisher, in reply, said:—Mr. President,—

I regard the award of this Medal to me as to some extent a token that my efforts to find a *modus vivendi* between geologists and physicists have been appreciated by the Geological Society. I regret to say that the leading physicists, at least in this country, make no sign at present either of accepting or of rejecting my conclusions; but the important questions at issue seem on the point of receiving recognition from American mathematicians.

It is with peculiar pleasure that I shall treasure the Murchison Medal. I had the honour many years ago of a slight acquaintance with the distinguished Founder of this endowment, and I recollect still, how, at the reading of the first paper which I offered to this Society, Sir Roderick expressed approbation of my views, which were somewhat opposed to the strictly uniformitarian theories then chiefly in vogue. Words of encouragement falling from so great a man could not fail to be valuable to an amateur at his first venture before a learned Society; and that the same Society should after many years endorse in so appropriate a manner the favourable opinion which he expressed of my early effort affords me the greatest satisfaction.

In presenting the Lyell Medal to Mr. E. Tulley Newton, F.G.S., the President addressed him as follows:—Mr. Newton,—

The Council have awarded to you the Lyell Medal, with a sum of Twenty-five Pounds, in recognition of the valuable services you have rendered to British Palæontology. In addition to your well-known memoirs, "On the Chimæroid Fishes of the Cretaceous rocks," and "On the Vertebrata of the Forest-bed Series," published by the Geological Survey, you continue to contribute important papers to the Royal, Geological, and Zoological Societies, to the Geological Magazine, and to the Geologists' Association. Nor must we forget the very valuable synopsis of the Animal Kingdom brought out by you in 1887.

Your knowledge of the fossil Mollusca has been made available by way of joint contribution to more than one paper, while you have further increased our knowledge of the Vertebrata of the British Isles in almost every class. The fishes have always constituted one of your favourite subjects, and lately you have brought to notice a new species of *Clupea* from the Oligocene of the Isle of Wight, and a form of *Semionotus* from the Keuper of Warwick, besides contributing to the history of Eocene Siluroids. Your recent papers in the "Proceedings" of the Royal Society

prove that you have not neglected the Reptilia, while your "Further Contributions to the History of the Norfolk Forest-bed" and your notice of some new Mammals from the Crags show that the Mammalia have not been forgotten. Even in the class Aves you have indicated the presence of the Red-throated Diver in Pleistocene Beds at Mundesley and more recently described *Gastornis Klaasseni* from the Lower Eocene of Croydon.

In presenting you with this token of their appreciation of your work, the Council feel sure that you are by no means likely to relax those efforts in descriptive palæontology which have already borne such excellent fruit.

Mr. Newton, in reply, said:—Mr. President,—

I am deeply sensible of the honour which the Geological Society has conferred upon me to-day, by the Award of the Lyell Medal, and regret that the work, of which you, Sir, have spoken so kindly, bears so small a proportion to the reward bestowed upon it; for the Medal of Sir Charles Lyell is in my estimation one of the highest honours which a geologist can hope to receive.

It has been my good fortune to have been placed in a position which has brought me valuable specimens to work out, and if the results of my labour are in any way of scientific value, it is due to training, in years gone by, under my esteemed master in science, the Rt. Hon. Professor Huxley.

I receive this Award with the greater pleasure, because it is to me a further evidence of the kindly feeling existing between this Society and the members of the Geological Survey, who are to-day rejoicing and participating in the honours conferred upon two of their colleagues.

I desire to express my warmest thanks to the Council for their much valued Award, and to you, Sir, for the kind words with which it has been accompanied.

In handing the Bigsby Medal, awarded to Prof. W. J. Sollas, D.Sc., LL.D., M.A., F.R.S., F.G.S., to Mr. J. J. H. Teall, M.A., F.R.S., F.G.S., for transmission to the recipient, the President addressed him in the following words:—Mr. Teall,—

The Council have awarded to Prof. Sollas the Bigsby Medal in acknowledgment of his continued researches on the morphology and mineral constitution of the fossil Sponges. Fifteen years have elapsed since a President of this Society, in presenting him with the balance of the proceeds of the Wollaston Donation Fund, expressed a belief that he would continue to benefit palæontological science by his researches on these obscure forms of life. That those anticipations have been fully realized, the important character of Prof. Sollas's subsequent work in this direction most clearly proves.

But it is not in Palæontology alone that he has evinced his interest in Geological Science, as his paper on the Silurian district of Rhymney and other contributions to the geology of the neighbourhood of Bristol serve to demonstrate. Nor have his efforts relaxed since he became Professor of Geology and Mineralogy in the University of Dublin, as the "Transactions" of the Royal Dublin Society and the Royal Irish Academy can testify. We recognize the philosophical biologist in his memoir on the Origin of Freshwater Faunas, and the mineralogist and chemist in his contributions to a knowledge of the Granites of Leinster. It is satisfactory to reflect that one who has done so much and in so many ways for science is still sufficiently young to receive the Bigsby Medal, and should he happily be spared, it is not unreasonable to suppose that still higher honours may await his efforts.

Mr. Teall, in reply, said:—Mr. President,—

I have been requested by my friend Prof. Sollas to express his thanks to the Council of the Geological Society for the honour which they have conferred upon him. Had he been present in person I feel sure that he would also have thanked you, Sir, for the kind words with which you have accompanied the Award. He desires me to read the following communication:—

"If the first impulse in the study of science arise from a longing for deeper insight into Nature, a second, at once powerful and innocent, is a desire for the approbation of elders. Thus I gratefully receive this Bigsby Medal awarded me by the Council, finding in it both reward, too little deserved, and stimulus to fresh endeavour.

"My old friend and whilom fellow-student, Mr. Teall, who, by the indulgence of the Society, represents me to-day, was its recipient in 1889, and he concluded his

expression of thanks with an eloquent tribute to our revered teacher, Prof. Bonney. Here I can gladly follow where I fain would lead; for if any success has attended my studies, I owe it to the encouragement of our old tutor, who has never treated the designation 'in loco parentis' as a harmless College fiction, but has made of it through life a veritable truth."

The PRESIDENT then handed the Balance of the Proceeds of the Wollaston Fund, awarded to Mr. J. G. Goodchild, F.G.S., to Prof. T. McKenny Hughes, M.A., F.R.S., F.G.S., for transmission to the recipient, addressing him as follows:—Professor Hughes,—

The Council, in awarding the Balance of the Proceeds of the Wollaston Donation Fund to Mr. Goodchild, have been desirous of expressing their sense of the value of his geological work in the North-west of England, and more especially of his description of the Glacial phenomena of the Eden Valley, as recorded in the Quarterly Journal of the Society. They also recognize his services in aid of science generally for many years past as Editor of the "Transactions" of the Cumberland and Westmoreland Association, and as the author of many interesting papers on Local Geology which have appeared in those "Transactions." The Council hope that his appointment in Edinburgh will not prevent him from still carrying on investigations in the field.

Professor HUGHES, in reply, said:—Mr. President,—

I have, as the oldest friend of Mr. Goodchild in this Society, been asked to receive and transmit to him the Proceeds of the Wollaston Fund. I feel more inclined to dilate upon my friend's deserts than upon the kindness of the Council in making the award to him.

I will try to compromise the matter by saying only that there is no man who will so keenly appreciate this recognition of his work, and no case in which the Society may reckon on a better return for this wholesome stimulus of encouragement.

In presenting the Balance of the Proceeds of the Murchison Geological Fund to Mr. G. J. Williams, F.G.S., the PRESIDENT addressed him as follows:—Mr. Williams,—

The Balance of the Proceeds of the Murchison Geological Fund has been awarded to you by the Council in token of appreciation of your active researches amongst the Cambrian and Ordovician rocks of Ffestiniog and Harlech. You have done good petrological and palæontological work, both in the selection of rocks for thin sections, and in amassing a fine series of fossils. The exhibition of a portion of your collection at Chester, on the occasion of the International Congress Excursion in 1888, proved to be of great interest. The Council hope that this award may be fruitful in inducing you to persevere on the lines which you have already adopted with so much success.

Mr. WILLIAMS, in reply, said:—Mr. President,—

I beg to thank the Council of the Geological Society for the wholly unexpected honour they had conferred on me in awarding me the Balance of the Proceeds of the Murchison Geological Fund. I have been able to do but little work in the past, and I look upon this award as an aid to further research rather than a recognition of work already accomplished. If anything is needed as an incentive to further work, in addition to the pleasure derived from the work itself, I shall be able to look back on this Award as a "spur to prick the sides of my intent."

The PRESIDENT then handed one moiety of the Balance of the Proceeds of the Lyell Geological Fund, awarded to Miss Catherine A. Raisin, B.Sc., to Prof. T. G. Bonney, D.Sc., LL.D., F.R.S., V.P.G.S., for transmission to the recipient, addressing him as follows:—Professor Bonney,—

In asking you to forward to Miss Raisin one moiety of the Balance of the Proceeds of the Lyell Geological Fund, I am performing a very pleasing duty. Miss Raisin's excellent work, both in the field and with the microscope, so far commends itself to the Council that they have readily made this Award to a pupil of whom you may be justly proud. The considerable number of papers which that lady has contributed, both to the "Quarterly Journal," of the Geological Society and also to the GEOLOGICAL

Magazine—all within the last six years—is a proof of her industry, while the papers themselves indicate an excellent knowledge of Petrology and a good eye for country. The Council, in making this Award, wish it to be regarded as an acknowledgment of past work, and at the same time as an encouragement for the future.

Professor Bonney, in reply, said:—Mr. President,—

I have been requested by Miss Raisin to offer her thanks to the Council and Society in the following terms:—

"It is difficult for me to express the gratification which I feel at the honour that has been conferred upon me by the Council of the Geological Society. It gives me also peculiar pleasure to receive an award associated with the name of Sir Charles Lyell, whose 'Principles of Geology' was one of the earliest books to arouse my enthusiasm in that subject, and who by the terms of his Bequest gave evidence of an interest in the intellectual work of women, and even anticipated that they might in the future take part in scientific investigations. In addition to the personal honour, I welcome this recognition as an encouragement, not to myself only, but also to other women who are working at Geology and at different branches of Natural Science. I can assure the Society that their generous appreciation of the little which I have done will not be thrown away, but that I shall use my best endeavours in the future to carry on work worthy of their kind encouragement, worthy also of the instruction and guidance received at University College, the benefit of which I rejoice to have this opportunity of acknowledging."

Here I might sit down, but I cannot forbear from expressing my personal gratification at being chosen to represent so earnest and conscientious a worker. It brings me a further gratification. As life is in its afternoon we become conscious, often painfully, that we have failed in fulfilling our earlier ideals. My own work has been smaller in quantity and inferior in quality to what I had hoped, but, when one former pupil receives an Award and another a Medal, when the Secretaries designated for the coming year are two other old pupils, one feels that one has not wholly laboured in vain.

The President then presented the other half of the Balance of the Proceeds of the Lyell Geological Fund to Mr. Alfred N. Leeds, addressing him as follows:—Mr. Leeds,—

The Council have awarded to you the second moiety of the Balance of the Proceeds of the Lyell Geological Fund, in appreciation of your long-continued and successful endeavours to collect and reconstruct the fossil Vertebrata of the Oxford Clay of the neighbourhood of Peterborough. In making this Award the Council bear in mind the readiness you have at all times shown to place the materials in your possession at the service of palæontologists desirous of availing themselves of your treasures. The Fund now awarded, besides being a recognition of past services, may serve to encourage you to work in the same direction.

Mr. Leeds, in reply, said:—Mr. President,—

In returning thanks to yourself and the Council for this Award, I must say how astonished and pleased I was at so unexpected a recognition. It is more than twenty years since my brother (who now resides in New Zealand) and I began to collect fossils from the Oxford Clay. The late Prof. Phillips, of Oxford, was the first geologist to describe some of our specimens, which are also figured in his "Geology of Oxford." In 1874 Prof. Seeley described the remains of *Muræenosaurus*, and since then he, Mr. J. W. Hulke, Mr. R. Lydekker, and Mr. A. Smith Woodward have written many papers for your Society upon other specimens of Saurians and Fishes which we had collected. From all these friends, and especially from Dr. H. Woodward, we have received the very greatest encouragement in our work.

You, Sir, have crowned our labours to-day, by your generous approval and the stamp of the "Lyell Award."

The President then proceeded to read his Anniversary Address, in which he first gave Obituary Notices of several Fellows and Foreign Members deceased since the last Annual Meeting, including Sir Richard Owen (elected in 1837), Mr. John Murray (elected in 1828), Col. T. W. Fletcher (elected in 1842), Mr. H. F. Blanford,

Mr. T. Davies, Mr. H. J. Marten, Mr. Edw. H. Hargraves, Mr. Wm. Reed, Sir Jas. Brunlees, Mr. L. L. Dillwyn, Mr. A. Norman Tate, Mr. D. Corse Glen, Mr. Thos. Wynne, Major-General N. von Kokscharow (elected Foreign Member in 1879), and Professor J. S. Newberry (elected Foreign Member in 1883).

The other portion of the Address dealt with some recent work of the Geological Society, the subjects ranging over a period of six or seven years. These embraced Pleistocene Geology, Theories in connexion with Glaciation, Tertiary, Cretaceous, Jurassic, and Permo-Triassic Geology. The address further mentions that the number of papers on Pleistocene Geology has been very considerable, and many of them relate to the South-east and the South of England; those relating to Central England and South Wales were fewer in number, whilst the North had furnished but few papers. The great memoir on the Westleton Beds had provided much material for consideration, that portion relating to the Southern Drift being especially interesting. Reference was made to a paper on the Pleistocene succession in the Trent Basin, as forming a fitting introduction to the fascinating problems connected with the North Wales border on the one side, and with Flamborough Head on the other. From Scotland, notice was taken of some supplementary remarks on the Parallel Roads of Glen Roy. Speculations as to the evidence of a Palæozoic Ice-age, the date and duration of the Pleistocene Glacial Period, and a notice on misconceptions regarding the evidence of former Glacial Periods were also discussed.

The Tertiary Geology of the London and Hampshire Basins was considered, more especially in relation to the Upper Eocene, or Bartons, and their probable equivalents in West Surrey. Under this heading also comes the Geology of Barbados, since the Oceanic deposits in that island were held to be of late Tertiary age. These interesting discoveries were reviewed at some length, and the results compared with tables in the recently-issued 'Challenger' Reports. In Upper Cretaceous Geology the phosphatic deposits at Ciply and Taplow were noticed, and also the important correlations of the basement-beds in Norfolk, Lincolnshire, and East Yorkshire. The Lower Cretaceous beds at Speeton next passed under review, more especially in connexion with their somewhat difficult palæontology and possible equivalents in Eastern Europe. The address then went on to state that our knowledge of the Upper Jurassics of the East of England had of late years received considerable additions, that important correlations between our Upper Jurassic generally and their equivalents in the Jura had been effected, and that the Inferior Oolite and the Lias-boundary had received their share of attention, while a determined attempt had been made to refer a portion of the Red Rocks of South Devon to the Permian formation.

The Ballot for the Council and officers was taken, and the following were duly elected for the ensuing year:—*Council:* Prof. J. F. Blake, M.A.; Prof. T. G. Bonney, D.Sc., LL.D., F.R.S.; R. Etheridge, Esq., F.R.S.; Sir A. Geikie, D.Sc., LL.D., For.Sec.R.S.; Prof. A. H. Green, M.A., F.R.S.; Alfred Harker, Esq., M.A.; H. Hicks, M.D., F.R.S.; G. J. Hinde, Ph.D.; T. V. Holmes, Esq.; W. H. Hudleston, Esq., M.A., F.R.S., F.L.S.; J. W. Hulke, Esq., F.R.S.; Prof. J.

W. Judd, F.R.S.; R. Lydekker, Esq., B.A.; Lieut.-General C. A. McMahon; J. E. Marr, Esq., M.A., F.R.S.; H. W. Monckton, Esq., F.L.S.; Clement Reid, Esq., F.L.S.; F. Rutley, Esq.; J. J. H. Teall, Esq., M.A., F.R.S.; Prof. T. Wiltshire, M.A., F.L.S.; Rev. H. H. Winwood, M.A.; Henry Woodward, LL.D., F.R.S.; H. B. Woodward, Esq.

OFFICERS:—*President:* W. H. Hudleston, Esq., M.A., F.R.S., F.L.S. *Vice-Presidents:* Sir A. Geikie, D.Sc., LL.D., For.Sec.R.S.; G. J. Hinde, Ph.D.; Prof. J. W. Judd, F.R.S.; Henry Woodward, LL.D., F.R.S. *Secretaries:* J. E. Marr, Esq., M.A, F.R.S.; J. J. H. Teall, Esq., M.A., F.R.S. *Foreign Secretary.* J. W. Hulke, Esq., F.R.S. *Treasurer:* Prof. T. Wiltshire, M.A. F.L.S.

II.—February 22nd, 1893.—W. H. Hudleston, Esq., M.A., F.R.S., President, in the Chair. The following communications were read:—

1. "On the Microscopic Structure of the Wenlock Limestone, with Remarks on the Formation generally." By Edward Wethered, Esq.

Microscopic sections of limestone have been examined from May Hill, Purley, and Ledbury, and the exposures of Wenlock Limestone were visited by the author. As a result of their study, it appears that these limestones have been deposited under varying local conditions. At May Hill, the Wenlock Limestone shows three divisions:—at the base of the quarry a massive limestone, succeeded by thin-bedded limestones separated by shales, and above these a nodular, irregularly-bedded limestone. The limestone of this district shows abundance of granules similar to Oolitic ones, and it is marked by the occurrence of *Girvanella problematica*, with new and important forms of the genus *Girvanella*.

At Purley, near West Malvern, is a section somewhat similar to that at May Hill. Pisolite has been described from this area, and the author succeeded in finding a weathered block of limestone full of pisolites, whilst sections from the beds at the base of the quarry show them to be more or less oolitic. Amongst other *Girvanellæ*, a form occurs at Purley which has not been noticed at May Hill.

The Ledbury limestone is very different from those at May Hill and Purley. The variety of calcareous organisms which appear to have contributed to its formation is small. No sign of oolitic structure has been found here, and *Girvanella* is only represented by occasional aggregations of *G. problematica*, whilst the extraordinary number of forms obtained from May Hill and Purley shows in how great a measure the tubules of this organism have contributed to the formation of the limestones of those places.

The author at present offers no opinion as to whether *Girvanella* is animal or vegetable.

2. "On the Affinities of *Anthracoptera*, and of *Anthracomya*." By Dr. Wheelton Hind, B.S., F.G.S.

In this paper the author gives the generic characters of the genera *Anthracoptera* and *Anthracomya*, and discusses their affinities. He gives reasons for supposing that the forms referable to these two genera lived in fresh water. The following species are described:—(i) *Anthracoptera modiolaris*, Sow., *A. triangularis*, Sow., *A. carinata*, Sow., *A. quadrata*, Sow., *A. tumida*, Eth. jun., *A. obesa*, Eth. jun., *A. elongata*, n.sp.; (ii) *Anthracomya Adamsi*, Salt., and var. *expansa*, Hind, *A. dolobrata*, Sow., *A. Phillipsii*, Williamson, *A. scotica*, Eth. jun., *A. modiolaris*, Salt., *A. elongata*, Williamson MS., *A.*

lanceolata, n.sp., *A. obtusa*, Ludwig, *A. angusta*, n.sp., *A. subcentralis*, Salt., *A. pumila*, Salt., *A. senex*, Salt., *A. obovata*, n.sp., *A.* n sp., *A. Wardi*, Salt. MS.

3. "Geological Remarks on certain Islands in the New Hebrides." By Lieut. G. C. Frederick, R.N. (Communicated by Sir Archibald Geikie, D.Sc., For.Sec.R.S., V.P.G.S.)

As far as can be judged from the soundings obtained, the New Hebrides are probably situated on a bank lying from 350 to 400 fathoms below the surface of the ocean and running in a N.N.W. and S.S.E. direction, with a deep valley between it and New Caledonia. The only two soundings obtained between these two groups are 2375 and 2730 fathoms, the former within a short distance of the New Hebrides.

Of the Islands, Tanna is volcanic—an active volcano, apparently consisting entirely of fragmental material, being situate on its eastern side. Efaté has some volcanic rock, but is chiefly of coral formation. It rises to a height of 2203 feet, and in some parts has a terraced appearance, the terraces denoting distinct periods of upheaval. Coral was found to the height of 1500 feet above sea-level. To the north of Efaté are Nguna, Pele, and Mau, of volcanic origin, and no coral has been found on them above sea-level; whilst Moso, Protection, and Erratáka, to the west of Efaté, are of coral formation and similar in character to the adjoining coast of Efaté. In the vicinity of the coral isles is very little coral-reef, especially when the shores are steep. Delicate live corals were brought up from depths of 28, 39, and 42 fathoms off Moso, 37 fathoms near Mau, and 40 fathoms off Mataso. Mataso is a volcanic island with a narrow fringing-reef. Makura (six miles N. of Mataso) and Mai are also volcanic with narrow fringing-reefs partly surrounding the former and entirely encircling the latter island. A short distance west of Mai is Cook's Reef, of atoll formation. The Shepherd Isles are all of volcanic formation, apparently recent, and no coral was found growing around their shores. Mallicolo Island is of volcanic and coral formation. At one place in this island coral was found at a height of about 500 feet above sea-level.

III.—March 8th, 1893.—W. H. Hudleston, Esq., M.A., F.R.S., President, in the Chair. The following communications were read:

1. "On the Occurrence of Boulders and Pebbles from the Glacial Drift in gravels south of the Thames." By H. W. Monckton, Esq.

North of the Thames near London, the Glacial Drift consists largely of gravel, which is characterized by an abundance of pebbles of red quartzite and boulders of quartz and igneous rock. With the exception of very rare boulders of quartz, the hill and valley gravels of the greater part of Kent, Surrey, and Berkshire are entirely free from these materials. The author points out that the river Thames is not, however, the actual southern boundary of the distribution of these Glacial Drift pebbles and boulders, though the number of localities where they are found in gravels south of that river is few. The author describes or mentions several, of which the following are the most important:—Tilehurst, Reading, Sonning,

Bisham at 351 feet above the sea, Maidenhead, Kingston, Wimbleton, and Dartford Heath.

2. "On the Plateau-Gravel south of Reading." By O. A. Shrubsole, Esq., F.G.S.

This paper contains observations on the gravel of the Easthampstead-Yately plateau. The constituent elements of the gravel are described, and the author notes pebbles of non-local material near Cæsar's Camp, Easthampstead, on the Finchampstead Ridges, and at Gallows Tree Pit at the summit of the Chobham Ridges plateau. He mentions instances of stones from the gravel of the plateau (described in the paper) which may bear marks of human workmanship. He furthermore argues that the inclusion of pebbles of non-local origin in the gravels may be due to submergence of the plateau up to a height of at least 400 feet above present sea-level, and cites other facts in support of this suggestion. He concludes that the precise age of the gravel can only be more or less of a guess, until the mode of its formation has been definitely ascertained.

3. "A Fossiliferous Pleistocene Deposit at Stone, on the Hampshire Coast." By Clement Reid, Esq., F.L.S., F.G.S. (Communicated by permission of the Director-General of the Geological Survey.)

This is practically a supplement to a paper, "On the Pleistocene Deposits of the Sussex Coast," that appeared in the last volume of the Quarterly Journal. An equivalent of the mud-deposit of Selsey has now been discovered about 20 miles farther west, and from it have been obtained elephant-remains, and some mollusca and plants like those found at Selsey. Among the plants is a South European maple.

OBITUARY.

DR. OTTOMAR NOVAK.

Born November 16th, 1851. Died July 29th, 1892.

An enthusiastic clear-minded student of Palæozoic fossils, including the Phyllocarids, in which the writers have been especially interested, has unfortunately passed away at the early age of 42. When last he wrote to one of us, in April, 1892, after his paper on the *Discinocaris Dusliana* had been published in the Geol. Mag., he said "I am somewhat better this year and hope to recover completely during the summer." How sadly this hope was frustrated we know by his death in July of that year.

Dr. Ottomar Novák was Conservator of the Geological Collections in the Museum of Prague during the years 1885–6. He filled the chair of Geology in the University of Prague 1888–92, and was continuing the researches of the illustrious Barrande in the Silurian faunas of Bohemia at the time of his death.

The following is a list of some of the Scientific papers published by Dr. Novák:—

1. Remarques sur le Genre Aristozoë, Barrande (Sitzungsb. k. böhm. Gesell. Wissen. Jahrgang, 1885) showing that *Bactropus longipes*, Barrande, and *Ceratiocaris debilis*, Barr., constitute the abdominal segment and caudal appendage of *Aristozoë Regina*, Barr.
2. Nouveau Crustacé Phyllocaride de l'Etage F—f 2 en Bohême (Sitz. k. böhm. Ges. Wiss. Jahrg. 1885. Prag, 1885). *Ptychocaris simplex* and *Pt. parvula*.

3. Zur Kenntniss der Fauna der Etage F—f 1 in der palæozoischen Schichtengruppe Böhmens (Sitz. k. böhm. Ges. Wiss. Jahrg. 1886. Prag, 1886).
Machæracanthus Bohemicus, Barrande, removed from *Ctenacanthus*.
Added to the Faunal List, which is given in full, as consisting of 128 species:—
Gyroceras Kayseri, nov. sp.
Tentaculites acuarius, Richter.
Hyolithes (*Orthotheca*) *intermedius*, nov. sp.
Aristozoë solitaria, nov. sp.
Ceratiocaris modesta, n. sp. MS.
—— *Damesi*, n. sp. MS.
Nautilus Alinæ, nov. sp., from Etage E—e 2, is also figured and described in the Appendix. The relationship of *Cryptocaris* to *Hyolithes*, as its operculum, is fully proved (see also Prof. Novák's Memoir on the Tentaculites of the Silurian strata of Bohemia in the Beiträge zur Paläontologie Osterreich-Ungarns, vol. ii. 1882.
4. Note sur Phasganocaris, nouveau Phyllocaride de l'Etage F—f 2, en Bohême. (Sitz. k. böhm. Ges. Wiss. Jahrg. 1886. Prag, 1886).
5. On the Occurrence of a new form of *Discinocaris* in the Graptolitic Beds of the "Colonie Haidinger" in Bohemia (Geol. Mag. Dec. III. Vol. IX. No. 334, August, 1892).

Most of Dr. Novák's valuable discoveries in the history of the Phyllocarids have been noticed in our Reports to the British Association. (See also Neues Jahrb. 1893, pp. 1–6.)

H. W. and T. R. J.

HENRY FRANCIS BLANFORD.

Henry Francis Blanford was born in 1834 in Bouverie Street, Whitefriars, where his father had a manufactory, now the "Daily News" Printing Office. His early education was obtained at private schools in Brighton and Brussels, and after studying for some time at the old School of Design in Somerset House he joined the Royal School of Mines at its first commencement in 1851, and a life that might otherwise very possibly have been devoted to art, for he was an admirable draughtsman, was thenceforward gained to science. At the Royal School of Mines he took the first place in his year, and received the Duke of Cornwall's Scholarship, then the only prize. After a year's study in Freiberg and another year in London, which he employed in preparing a translation of Scheerer's work on the blowpipe, his first publication, he was appointed to the staff of the Geological Survey of India together with his brother, Mr. W. T. Blanford, and landed in Calcutta at the end of September, 1855.

Almost immediately after their arrival in India, the two brothers and Mr. W. Theobald were despatched to examine and report upon an almost unknown Coalfield around Talchir in Orissa. The work done was chiefly memorable geologically for one discovery, that of the Talchir Boulder bed, and for the circumstance that, chiefly through Mr. H. F. Blanford's observations. the first step was taken towards the classification of the remarkable series of beds associated with the Indian Coal-bearing rocks, for both the underlying Talchir division and an overlying mass were separated from the Damuda or true Coal-bearing beds. For some time after this Mr. H. F. Blanford was engaged in Calcutta in charge of the Survey Office and was occupied with Palæontological work in the Museum; but in 1857 he was placed at the head of a strong survey party that was despatched to Madras, and he was chiefly engaged for the next three

or four years in examining the Cretaceous beds near Trichinopo and Pondicherry, some fossils from which, described by Prof. Forbes and Sir P. Egerton, had attracted much attention in Europ The stratigraphical work on the Indian Cretaceous beds was main palæontological, but the classification established by Mr. Blanfor was fully confirmed by Dr. F. Stoliczka's well-known description the fauna. A commencement of this description was made by M Blanford himself, who published an account of the Nautilidæ an Belemnitidæ in the "Palæontologia Indica" before he left the Surve in 1862. The geology of the area was described in a report pul lished in the fourth volume of the Memoirs of the Geological Surve of India. An account of the geology of the Nilghiri Hills in th first volume of the same Memoir was the only other report on th Madras Presidency by Mr. Blanford published by the Survey.

The causes of Mr. Blanford's retirement from the Survey wer partly injury to his health caused by exposure to the climate, partl strained personal relations with the Superintendent of the Survey the late Dr. T. Oldham. After staying for a short time in Europ and recovering his health Mr. Blanford was appointed to the Scienc Professorship at the Presidency College, Calcutta, and was fro 1864 to 1872 on the staff of the Bengal Educational Departmen He became in 1864 one of the Hon. Secretaries of the Asiatic Societ of Bengal, and about this time took up the subject of India Meteorology, at first in connection with cyclonic storms, of whic a very severe one visited Calcutta in 1864. He was for some years member of a Meteorological Committee appointed by the Governmen but in 1867 he became Meteorological Reporter to the Government Bengal, and finally in 1874, a new department having been forme by the Government of India, he was placed at the head. This pos of Meteorological Reporter to the Government of India he hel until his retirement from Indian service in 1888. After his retire ment he resided at Folkestone until his death on January 23rd of th present year.

Besides a number of important reports and works on Meteorology Mr. Blanford was author of several papers on fossil and recen Mollusca, and of two treatises on the geography of India. One o these has been used for many years as a text-book by schools an colleges in India; the other is a recent publication and forms one o Macmillan's geographical series, published under the editorship o Sir A. Geikie. Another recent publication of Mr. Blanford's is "A Practical Guide to the Climates and Weather of India, Ceylon, an Burma, and the Storms of Indian Seas." He also wrote, in con junction with the late Mr. J. W. Salter, the Palæontology of Niti His only contribution to the Quarterly Journal of the Geologica Society was an important paper published in 1875 on "The Age an Correlation of the Plant-bearing Series of India and the forme existence of an Indo-Oceanic Continent."

Mr. H. F. Blanford became a Fellow of the Geological Society i 1862 and of the Royal Society in 1880. He was President of th Asiatic Society of Bengal in 1884–85.